This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

HARVARD UNIVERSITY

LIBRARY OF THE
MINERALOGICAL
LABORATORY

UNIVERSITY MUSEUM

Department of
Mineralogy & Petrography
HARVARD UNIVERSITY
CAMBRIDGE, MASS.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 11

RIVER HEIGHTS, 1896.—DAVIS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1897

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal relating to water supply and irrigation prepared by the United States Ge Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890, octavo, 1!

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States G Survey, 1888–89. Contains a statement of the origin of the Irrigation Survey, a pr report on the organization and prosecution of the survey of the arid lands for purpos gation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891, octavo,

Published as Part II, Irrigation, of the Eleventh Annual Report of the United State ical Survey, 1889–90. Contains a description of the hydrography of the arid region a... engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891, octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890–91. Contains a report upon the location and survey of reservoir sites during the fiscal year ending June 30, 1891, by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell, quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892, quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, Part III, Irrigation, 1893, octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American engineering and engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893, octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894, quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical condition and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, in two parts, Part II, Accompanying papers, 1894, octavo, 597 pp.

Contains papers on "potable waters of the eastern United States," by W. J. McGee; "natural mineral waters of the United States," by A. C. Peale; "results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 11

WASHINGTON
GOVERNMENT PRINTING OFFICE
1897

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

RIVER HEIGHTS FOR 1896

BY

ARTHUR POWELL DAVIS

WASHINGTON

GOVERNMENT PRINTING OFFICE

1897

CONTENTS.

	Page.
Daily gage heights observed during 1896, arranged in geographic order by drainage basins	7
Current meters rated in 1896	93
Drainage-area measurements	95

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, June 1, 1897.

SIR: I have the honor to transmit herewith a series of tables pertaining mainly to river heights, prepared by the Division of Hydrography of this Survey, and to recommend that it be published in the series of papers "in relation to the gauging of streams and to the methods of utilizing the water resources," the printing of which was authorized in the act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1897, approved June 11, 1896.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RIVER HEIGHTS FOR 1896.

By ARTHUR P. DAVIS.

DAILY GAGE HEIGHTS OBSERVED DURING 1896.

The series of tables here presented pertain mainly to the river heights observed and recorded during 1896 by persons employed by or cooperating with the Division of Hydrography of this Survey. There are also included a few tables obtained from the Weather Bureau through the courtesy of Hon. Willis L. Moore, chief of that Bureau. These give the heights of water at points near localities where measurements have been made by hydrographers of this Survey, and are of value in computations of discharge. A few similar tables have been obtained through officers of the Engineer Corps of the United States Army, from observations made in connection with investigations pertaining to the improvement of navigation. There are appended tables of evaporation, seepage, meter ratings, and other similar details to which reference is made by hydrographers of this Survey.

These tables pertain to the progress report of stream measurements for 1896, prepared by the Division of Hydrography and printed in Part IV of the Eighteenth Annual Report of the Survey. They might properly have been included in the progress report, but since they relate to minor details and have a comparatively limited application, it has been thought best, from considerations of economy and from the necessity of reducing the size of the annual report, to include these in a separate publication of more limited distribution. On the other hand, these data should be printed and thus made available for the use of hydrographers, not only those connected with this Survey, but others occupied in similar examinations throughout the country.

Patapsco River at Woodstock, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.55	3.85	3.70	4.05	17	3.70	3.60	3.70	.....	3.65
2	.....	3.50	3.65	3.70	4.00	18	3.70	3.60	3.70	.....	3.70
3	.....	3.45	3.60	3.70	3.95	19	3.70	3.60	3.65	3.90	3.65
4	.....	3.50	3.60	3.75	3.75	20	3.65	3.60	3.65	3.70	3.45
5	.....	3.65	3.65	3.90	3.75	21	3.55	3.70	3.70	3.65	3.65
6	3.60	3.85	3.65	4.10	3.85	22	3.35	3.20	3.70	3.70	3.65
7	3.70	3.85	3.65	3.95	3.90	23	3.40	3.60	3.70	3.75	3.65
8	3.60	3.60	3.50	3.85	3.70	24	3.65	3.50	3.65	3.70	3.60
9	3.50	3.55	3.70	4.10	3.75	25	3.65	3.55	3.75	3.65	3.50
10	3.80	3.50	3.65	4.00	3.75	26	3.55	3.50	3.80	3.50	3.65
11	3.60	3.50	3.70	3.85	3.70	27	3.70	3.55	3.70	3.65	3.65
12	3.70	3.50	3.85	3.80	3.70	28	3.50	3.50	3.70	3.65	3.85
13	3.85	3.45	3.95	3.80	3.70	29	3.40	3.60	3.70	4.90	3.85
14	3.85	3.55	3.80	3.80	3.75	30	3.55	3.40	3.70	4.20	3.50
15	3.75	3.55	3.75	3.80	3.65	31	3.35	.....	3.70	.....	3.75
16	3.70	3.65	3.65	4.00	3.65						

Patuxent River at Laurel, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.20	4.75	3.15	4.75	17	4.60	4.50	3.80	4.50	4.40
2	.....	4.00	4.30	4.35	4.85	18	4.00	3.75	3.10	4.40	4.55
3	4.30	4.00	3.80	3.05	4.65	19	4.10	4.35	3.85	4.50	4.40
4	4.30	3.50	3.20	4.40	4.70	20	4.60	5.10	3.90	4.50	3.20
5	4.10	4.20	3.95	4.60	4.75	21	4.60	3.90	4.45	4.50	4.60
6	4.20	4.50	3.75	4.65	3.95	22	4.40	3.75	4.30	3.00	4.50
7	4.00	4.00	3.80	4.80	4.85	23	3.60	3.65	4.45	4.65	4.30
8	4.00	3.30	3.75	3.25	4.75	24	4.40	3.80	4.40	4.30	3.85
9	3.50	3.30	3.75	4.80	4.75	25	4.60	3.70	3.25	4.30	4.15
10	3.90	4.30	3.80	4.45	4.70	26	4.60	3.80	4.60	3.15	4.25
11	4.30	2.30	3.10	4.70	4.55	27	4.50	3.05	4.55	4.55	4.05
12	4.10	4.50	3.90	4.50	4.65	28	4.50	3.70	4.15	4.20	4.25
13	4.10	2.20	3.80	4.60	3.85	29	4.40	3.70	3.95	5.50	4.70
14	4.30	2.90	3.90	4.45	4.60	30	2.70	4.85	4.10	5.00	4.65
15	4.50	4.50	3.80	3.55	4.65	31	4.70	.....	3.95	.....	4.90
16	3.60	4.70	3.80	4.60	4.60						

Potomac River at Cumberland, Maryland.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.90	4.60	3.90	5.00	4.50	3.60	3.10	3.80	2.60	5.50	3.10	3.70
2	2.90	4.80	3.70	4.80	4.50	3.50	3.10	3.80	2.70	4.50	3.10	3.50
3	3.00	4.00	3.00	4.40	4.50	3.40	3.10	3.80	2.70	4.50	3.10	3.40
4	2.90	3.80	3.30	4.20	4.50	3.50	3.10	3.70	2.70	3.50	3.20	3.30
5	2.90	3.80	3.10	3.80	3.40	3.30	3.10	3.30	2.70	3.40	3.20	3.30
6	2.90	3.80	3.10	3.80	3.30	3.30	2.90	3.30	2.80	3.30	5.50	3.30
7	2.90	4.50	3.10	3.70	3.10	3.80	2.90	3.20	2.90	3.10	4.50	3.30
8	2.90	3.90	3.60	3.70	3.00	3.70	2.90	3.20	2.90	3.10	3.80	3.20
9	2.90	3.00	3.40	3.70	3.00	3.40	3.10	3.40	2.90	3.10	3.80	3.30
10	2.90	3.40	3.30	3.70	3.00	3.40	3.70	3.40	2.90	3.00	3.70	3.30
11	2.90	3.10	3.30	3.70	2.90	3.40	3.40	3.30	2.80	3.00	3.60	3.40
12	3.00	3.30	3.40	4.30	2.90	3.40	3.30	3.30	2.70	3.10	3.50	3.60
13	3.00	4.90	3.10	4.30	3.50	3.20	3.10	3.10	2.90	3.10	3.50	3.40
14	3.00	4.10	3.10	4.10	3.50	3.20	3.00	3.60	3.00	3.00	3.40	3.30
15	3.00	3.80	3.10	3.90	3.30	3.30	3.00	3.50	3.10	3.00	3.20	3.30
16	3.00	3.80	3.20	3.80	3.20	3.30	3.00	3.30	3.50	3.00	3.10	3.30
17	3.00	3.50	3.30	3.80	3.10	3.70	3.00	3.10	3.00	3.00	3.10	3.30
18	3.00	3.50	3.30	3.70	3.40	4.10	3.30	3.00	3.00	3.00	3.20	3.30
19	2.90	3.20	3.50	3.50	3.50	3.70	3.10	2.90	3.00	2.90	3.30	3.30
20	2.90	3.20	3.60	3.50	3.80	3.60	3.10	2.90	2.90	2.90	3.30	3.30
21	3.00	3.20	3.70	3.50	3.80	3.30	3.30	3.00	3.00	3.10	3.20	3.20
22	3.00	3.20	3.70	3.50	3.60	3.30	4.00	3.00	3.10	3.10	3.30	3.20
23	3.00	3.30	4.00	3.30	3.40	3.20	4.70	3.00	3.10	3.10	3.30	3.20
24	3.10	3.10	3.90	3.40	3.40	3.50	4.60	3.20	3.00	3.30	3.40	3.20
25	3.50	3.30	3.70	3.50	3.50	3.50	10.00	3.00	3.00	3.70	3.30	3.20
26	3.30	3.30	4.00	3.50	3.50	3.60	6.50	2.90	3.00	3.50	3.30	3.20
27	3.10	3.30	5.00	3.50	4.00	3.50	4.70	2.90	3.00	3.20	3.20	3.10
28	3.00	3.20	4.50	3.50	3.70	3.30	4.90	2.90	2.90	3.20	3.20	3.10
29	3.00	3.70	5.80	3.50	4.10	3.30	4.50	2.90	2.90	3.10	3.90	3.10
30	3.70	.....	8.00	3.40	4.00	3.20	4.50	2.90	10.00	3.10	4.00	3.10
31	4.20	.....	6.00	.....	3.80	.....	4.50	.....	.....	3.10	.....	3.20

North River at Port Republic, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	2.50	2.60	5.40	2.32	2.42	2.80	2.43	2.00	7.50	2.35	4.40
2	2.70	2.50	2.60	5.00	2.52	2.32	2.70	2.43	1.95	4.50	2.35	3.50
3	2.50	2.80	2.60	4.60	2.52	2.32	2.70	2.55	1.90	4.00	2.35	3.30
4	2.40	3.80	2.60	4.20	3.32	2.22	2.60	2.45	1.90	3.50	2.35	3.30
5	2.40	3.80	2.60	4.00	3.32	2 20	2.60	2.40	1.90	3.30	4.70	3.25
6	2.40	5.00	2.50	3.60	3.32	2.20	2.80	2.40	1.85	3.20	6.00	3.10
7	2.40	5.70	2.50	3.50	3.12	4.50	2.80	2.30	1 85	3.10	4.30	3.05
8	2.30	4.50	2.50	3.50	2.92	3.00	2.80	2.30	1.80	3.00	3.60	2.90
9	2.30	4.10	2.50	3.40	2.72	2.60	7.50	2.30	1.80	2.90	3.30	2.80
10	2.30	3.70	2.50	3.30	2.72	2.50	5.30	2.25	1.75	2.80	3.30	2.70
11	2.30	3.50	2.40	3.30	2.72	2.30	3.90	2.20	1.70	2.65	3.20	2.65
12	2.30	3.30	2.40	3.20	2.62	2.30	3.60	2.20	1.70	2.55	3.00	2.60
13	2.30	3.30	2.40	3.20	2.52	2.20	3.30	2.20	1.70	2.50	2.80	2.55
14	2.20	5.20	2.40	3.00	5.82	2.20	3.00	3.60	1.70	2.50	2.80	2.55
15	2.20	4.70	2.60	3.00	3.82	2.20	3.30	2.70	2.00	2.50	2.70	2.50
16	2.10	3.80	2.60	(a)	3.22	2.20	3.00	2.70	1.90	2.50	2.70	2.50
17	2.10	3.60	2.80	.....	3.02	2.50	3.10	3.00	1.80	2.50	2.65	2.45
18	2.00	3.10	3.20	.....	2.82	2.40	2.70	2.40	1.80	2.45	2.65	2.45
19	2.00	3.00	4.80	.....	2.62	2.40	2.70	2.30	1.80	2.45	2.60	2.45
20	2.00	2.70	7.20	.....	2.62	3.30	2.70	2.25	1.70	2.40	2.60	2.45
21	2.00	2.70	5.00	.....	2.62	3.00	2.60	2.25	1.70	2.40	2.55	2.45
22	2.00	2.70	4.80	.....	2.62	2.90	2.50	2.25	1.70	2.35	2.50	2.45
23	2.10	2.70	4.00	.....	2.62	2.50	2.50	2.20	1.70	2.35	2.50	2.45
24	6.15	2.70	3.80	.....	2.52	2.40	2.50	2.20	1.65	2.35	2.45	2.45
25	5.30	2.70	3.50	.....	2.52	2.40	3.00	2.40	1.65	2.35	2.40	2.40
26	4.00	2.60	3.50	.....	2.52	3.20	2.70	2.20	1.65	2.35	2.40	2.40
27	3.30	2.60	3.50	.....	2.52	3.00	2.70	2.20	1.65	.....	2.35	2.40
28	3.00	2.60	3.50	b 2.22	2.42	3.00	2.60	2.15	1.65	2.35	2.35	2.40
29	2.80	2.60	4.40	2.22	2.42	2.90	2.60	2.15	7.21	2.35	3.00	2.40
30	2.60	.....	6.50	2.22	2.42	2.90	2.50	2.10	18.00	2.35	5.50	2.40
31	2.50	.....	5.90	.....	2.42	.....	2.45	2.10	.....	2.35	.....	2.35

a Gage carried away. *b* New gage.

South River at Port Republic, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.00	2.00	3.20	1.70	1.60	1.80	1.50	1.40	5.00	1.60	2.70
2	1.80	2.00	2.00	3.00	1.70	1.50	1.80	1.50	1.40	3.30	1.60	2.55
3	1.80	2.30	2.00	2.80	2.20	1.50	1.70	1.50	1.40	3.00	1.60	2.40
4	1.70	2.50	2.00	2.70	2.20	1.50	1.60	1.50	1.40	2.75	1.60	2.40
5	1.60	2.50	2.00	2.50	2.20	1.50	1.60	1.50	1.40	2.40	4.10	2.35
6	1.50	3.15	1.90	2.50	2.20	1.50	1.70	1.45	1.40	2.30	3.50	2.10
7	1.40	3.60	1.90	2.40	2.10	2.50	1.70	1.45	1.40	2.30	3.00	2.10
8	1.40	3.10	1.90	2.30	2.00	2.50	1.70	1.40	1.40	2.20	2.60	2.00
9	1.30	3.10	1.90	2.30	1.90	2.50	4.80	1.40	1.40	2.10	2.40	1.90
10	1.30	2.70	1.90	2.20	1.90	2.00	3.20	1.40	1.40	2.00	2.30	1.80
11	1.30	2.50	1.85	2.20	1.90	1.80	2.70	1.40	1.40	2.00	2.15	1.70
12	1.30	2.30	1.85	2.20	1.80	1.80	2.50	1.40	1.40	1.95	2.15	1.60
13	1.30	2.30	1.85	2.20	1.70	1.70	2.40	1.40	1.35	1.95	2.10	1.50
14	1.20	2.80	1.85	2.15	3.00	1.60	2.30	2.00	1.35	1.90	2.10	1.50
15	1.20	2.70	2.00	2.15	2.00	1.60	2.30	1.60	1.35	1.85	2.00	1.50
16	1.20	2.50	2.00	2.10	1.80	1.60	2.00	1.60	1.35	1.85	2.00	1.45
17	1.20	2.40	2.20	2.00	1 80	2.50	2.00	1.60	1.35	1.85	1.90	1.45
18	1.20	2.30	2.20	2.00	1.70	2.20	1.70	1.50	1.35	1.85	1.90	1.45
19	1.20	2.30	2.80	1.90	1.60	2.20	1.80	1.50	1.35	1.85	1.85	1.45
20	1.20	2.20	4.30	1.90	1.60	2.50	1.80	1.50	1.35	1.80	1.85	1.45
21	1.20	2.20	3.00	1.90	1.60	2.00	1.70	1.50	1.35	1.75	1.80	1.45
22	1.20	2.20	2.60	1.80	1.60	2.00	1.70	1.50	1.30	1.70	1.80	1.45
23	1.30	2.10	2.60	1.80	1.60	1.80	1.70	1.50	1.30	1.65	1.80	1.45
24	4.90	2.10	2.50	1.80	1.60	1.70	1.70	1.50	1.25	1.65	1.80	1.45
25	3.60	2.10	2.50	2.00	1.60	1.70	1.70	1.65	1.25	1.65	1.75	1.45
26	3.00	2.00	2.40	2.00	1.60	2.00	1.70	1.50	1.25	1.65	1.70	1.45
27	2.70	2.00	2.40	1.90	1.60	2.00	1.70	1.50	1.25	.....	1.65	1.45
28	2.40	2.00	2.40	1.80	1.60	2.00	1.70	1.50	1.25	1.60	1.65	1.45
29	2.30	2.00	2.50	1.75	1.60	1.90	1.60	1.50	9.69	1.60	2.00	1.45
30	*2.20	.....	3.30	1.70	1.60	1.90	1.60	1.45	17.00	1.60	3.10	1.45
31	2.10	.....	3.20	.....	1.60	.....	1.50	1.45	.....	1.60	.....	1.45

Shenandoah River at Millville, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.40	2.60	4.60	1.40	0.90	1.60	1.30	0.70	19.72	0.90	2.60
2	1.90	1.60	2.40	4.20	1.40	.90	1.60	1.20	.60	10.00	.90	3.80
3	1.80	1.80	2.30	3.80	1.50	.90	1.50	1.10	.60	5.60	.90	3.10
4	1.80	2.00	2.00	3.60	1.70	.90	1.50	1.00	.60	4.00	.90	2.60
5	1.70	2.60	1.70	3.20	1.80	.90	1.50	1.00	.60	3.40	1.00	2.00
6	1.60	2.90	1.50	2.80	1.90	.80	1.50	1.00	.60	2.80	1.10	2.00
7	1.60	3.80	1.40	2.60	2.40	1.00	1.60	1.10	.50	2.10	3.20	2.00
8	1.60	5.60	1.50	2.60	2.20	1.40	1.60	1.10	.50	2.00	2.70	2.00
9	1.40	4.10	1.50	2.00	2.00	1.90	3.15	1.00	.50	1.90	2.40	2.00
10	1.30	3.70	1.50	2.00	2.00	2.70	4.65	1.00	.50	1.80	2.10	2.00
11	1.30	3.20	1.50	2.00	1.90	2.80	3.60	1.00	.60	1.80	1.90	1.90
12	1.20	2.90	1.40	2.00	1.70	2.40	2.50	1.40	.60	1.60	1.90	1.90
13	1.20	2.50	1.40	2.00	1.70	1.60	2.20	1.60	.60	1.40	1.90	1.80
14	1.00	2.40	1.40	1.90	1.60	1.60	2.20	1.50	.60	1.40	1.90	1.80
15	1.00	3.80	1.50	1.70	2.40	1.90	2.20	1.40	.60	1.40	1.90	1.70
16	1.00	3.50	1.50	1.70	3.00	1.90	2.20	1.40	.60	1.40	1.80	1.70
17	1.00	3.00	1.60	1.60	2.50	1.80	2.10	1.70	.60	1.30	1.70	1.70
18	1.00	2.70	3.00	1.60	2.40	1.90	2.00	1.50	.60	1.30	1.60	1.70
19	1.00	2.50	4.20	1.60	2.40	2.20	2.00	1.30	.60	1.30	1.60	1.70
20	1.00	2.40	4.60	1.50	2.20	2.00	1.80	1.20	.80	1.20	1.50	1.60
21	.90	2.40	5.50	1.50	1.80	1.90	1.60	1.20	.80	1.10	1.50	1.50
22	.90	2.30	4.60	1.50	1.60	2.00	1.50	1.20	.80	1.10	1.50	1.50
23	.90	2.20	4.00	1.50	1.50	2.20	4.10	1.00	.70	1.00	1.50	1.40
24	2.40	2.20	3.50	1.50	1.60	2.00	3.00	1.00	.60	1.00	1.50	1.40
25	5.10	1.80	3.00	1.50	1.50	1.90	3.30	1.00	.60	1.00	1.40	1.60
26	5.30	1.70	2.90	1.40	1.50	1.80	2.60	.90	.60	1.00	1.40	1.60
27	4.35	1.60	2.80	1.40	1.50	1.80	2.00	.90	.60	1.00	1.40	1.60
28	3.35	1.50	2.70	1.40	1.40	2.20	1.70	.80	.60	1.00	1.40	1.80
29	2.00	2.00	2.70	1.40	1.40	2.30	1.50	.80	.60	1.00	1.40	1.80
30	1.90	.....	2.60	1.40	1.40	1.90	1.40	.80	5.75	1.00	1.60	1.80
31	1.70	.....	4.60	.....	1.10	.....	1.30	.80	.....	.90	.....	1.80

Potomac River at Point of Rocks, Maryland.

Day.	Jan.	Feb.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.30	.....	1.10	1.60	2.00	0.50	21.85	0.80	2.00
2	1.20	1.20	.....	.80	1.40	2.20	.50	12.05	.80	3.00
3	1.30	1.30	.....	.60	1.20	2.50	.40	6.30	.70	2.80
4	1.40	1.80	.....	.50	1.10	2.00	.40	4.00	.70	2.30
5	.40	2.80	.....	.40	1.00	1.80	.40	3.00	.80	2.00
6	1.40	3.50	.....	.30	1.30	1.60	.50	2.40	6.00	1.80
7	1.30	6.80	.....	.60	1.20	1.40	.30	2.10	6.00	1.70
8	1.30	7.00	.....	.60	1.60	1.20	.30	1.80	5.10	1.70
9	1.30	5.00	.....	1.60	1.90	1.10	.30	1.50	3.80	1.60
10	1.30	3.80	.....	2.00	2.50	1.20	.30	1.30	3.00	1.50
11	1.00	3.90	0.80	2.20	4.00	1.10	.40	1.20	2.50	1.70
12	.80	2.80	.70	1.70	3.80	1.00	.30	1.10	2.20	1.70
13	.70	2.40	.60	1.40	2.70	1.00	.30	1.10	1.90	1.60
14	.60	2.30	.60	1.10	2.30	1.10	.30	1.00	1.70	1.50
15	.50	2.70	.50	1.00	2.30	1.10	.30	1.00	1.50	1.40
16	.50	3.90	1.60	1.10	1.60	1.10	.80	1.00	1.50	1.30
17	.50	3.50	1.10	1.20	1.50	1.20	.50	1.00	1.40	1.20
18	.40	2.90	1.00	3.40	1.40	1.00	.40	1.00	1.30	1.10
19	.30	2.30	.80	3.20	1.40	.80	.40	.90	1.20	1.00
20	.30	1.30	.60	2.70	1.30	.70	.70	.90	1.10	1.00
21	.30	.90	.60	2.20	1.20	.60	.40	.80	1.00	1.00
22	.50	1.10	.70	1.80	1.10	.60	.50	.80	1.00	1.00
23	.60	1.50	1.00	1.80	1.20	.60	.40	.80	1.00	1.00
24	2.30	1.50	1.90	1.80	1.60	.60	.40	.70	1.00	1.00
25	4.90	1.60	.90	1.60	3.30	.60	.30	.70	.90	.90
26	4.80	1.40	.80	1.70	8.70	.50	.40	.90	.90	1.10
27	3.70	1.30	.70	1.90	6.00	.50	.40	1.00	.90	1.00
28	2.90	1.20	.60	2.30	3.30	.50	.30	.90	1.00	.70
29	2.10	1.80	.80	2.00	2.70	.60	.40	.90	1.00	.70
30	1.60	.....	1.00	1.80	2.80	.60	5.30	.80	1.20	.80
31	1.40	.....	1.60	.....	2.40	.50	.....	.80	.....	.90

Monocacy River at Frederick, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.60	4.80	3.90	4.80	17	3.80	3.90	4.00	4.20	4.00
2	.....	3.60	4.40	4.00	4.50	18	4.40	3.90	3.90	4.20	4.00
3	.....	3.60	4.10	4.00	4.50	19	4.15	4.00	3.90	4.20	4.00
4	4.10	3.60	4.00	4.00	4.30	20	3.90	4.00	3.80	4.20	4.00
5	4.10	3.60	3.90	5.45	4.30	21	3.90	4.00	3.90	4.20	4.00
6	4.00	3.70	3.90	7.50	4.10	22	3.90	3.90	3.90	4.00	3.90
7	4.00	3.80	3.90	5.00	4.10	23	3.80	3.90	3.90	4.00	3.90
8	3.90	3.90	3.90	4.50	4.10	24	3.70	3.80	3.90	4.00	4.10
9	3.90	3.90	3.90	4.50	4.20	25	3.70	3.90	3.90	4.00	4.20
10	3.90	3.80	3.90	4.80	4.20	26	3.90	3.80	3.90	4.00	4.10
11	3.80	3.70	3.80	4.50	4.80	27	3.90	3.80	3.90	4.00	4.10
12	3.90	3.70	3.80	4.50	4.20	28	3.80	3.80	3.90	4.00	4.10
13	3.90	3.70	3.90	4.30	4.10	29	3.70	3.80	3.90	4.35	4.00
14	3.90	3.70	4.20	4.30	4.10	30	3.60	5.00	3.90	5.20	4.00
15	3.90	3.70	4.10	4.20	4.10	31	3.70	.....	3.90	.....	4.20
16	3.80	a3.75	4.10	4.20	4.10						

a New gage.

North River at Glasgow, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	1.80	1.90	5.25	.....	1.40	1.50	1.55	1.42	5.03	1.59	4.13
2	2.05	1.50	1.80	.....	.....	1.33	1.36	3.35	1.38	3.70	1.60	3.42
3	1.85	3.50	1.80	3.00	.....	1.25	1.32	2.24	1.40	2.90	1.60	2.50
4	(a)	2.80	1.76	.....	.....	1.30	1.50	1.90	1.46	2.70	1.60	2.50
5	1.33	(a)	1.72	.....	2.33	1.28	1.60	1.76	1.35	2.60	4.75	.....
6	1.35	4.20	1.68	2.76	2.12	1.23	1.40	1.54	1.35	2.40	4.85	2.40
7	(a)	4.15	1.63	2.60	1.97	1.23	3.22	1.62	1.38	2.30	3.35	2.30
8	1.37	4.35	1.62	2.40	1.86	1.24	(a)	1.50	1.35	2.15	2.90	2.20
9	1.40	.....	1.62	2.37	1.84	2.20	8.45	1.44	1.33	2.08	2.65	2.15
10	1.30	3.85	1.60	.....	1.84	1.95	4.45	1.36	1.30	2.00	2.42	2.11
11	1.25	2.60	(a)	.....	.....	1.60	3.50	1.32	1.28	1.96	2.30	2.01
12	1.22	2.50	1.66	.....	.....	1.42	.....	1.30	1.26	1.90	2.21	1.94
13	1.20	2.40	1.60	.....	3.40	1.35	2.78	1.50	.....	1.90	2.22	.....
14	1.20	4.40	1.58	2.02	2.50	1.96	2.40	.....	.....	1.88	2.11	1.90
15	1.18	4.00	1.60	.....	2.25	1.55	2.26	2.00	.....	1.82	2.02	1.90
16	1.15	3.05	2.85	1.94	1.82	1.50	2.20	1.72	.....	1.82	2.05	1.84
17	1.12	2.50	4.93	.....	.....	1.40	2.52	.....	1.00	1.80	2.01	1.80
18	1.12	2.25	3.65	1.90	.....	1.50	2.00	1.72	1.00	1.75	2.02	1.80
19	1.15	2.24	4.20	1.87	.....	1.62	1.82	1.60	1.00	1.71	2.00	1.78
20	1.19	2.14	5.25	.....	2.08	1.96	1.75	1.52	.98	1.70	2.01	1.75
21	1.17	2.05	4.00	.....	2.00	(a)	1.72	1.48	.95	1.71	1.95	1.70
22	1.12	1.95	3.12	1.80	1.74	1.46	1.65	1.40	.95	1.68	.....	1.70
23	(a)	1.90	(a)	.....	1.82	2.08	2.25	2.37	.96	1.70	.....	1.65
24	4.95	1.86	2.90	1.77	1.61	1.47	1.83	1.54	.90	1.70	.....	1.60
25	3.76	1.80	2.80	.....	1.60	1.47	1.80	2.25	.90	1.63	1.67	1.58
26	2.88	1.75	2.77	1.75	1.61	2.26	1.67	1.82	.93	1.67	.....	1.56
27	2.42	1.70	2.61	.....	1.59	2.58	1.60	1.70	.91	1.60	.....	1.56
28	2.20	1.70	2.51	.....	1.63	2.00	1.50	1.60	.90	1.63	.....	1.60
29	2.00	1.90	3.05	.....	1.61	1.74	1.50	1.50	4.04	1.63	.....	1.60
30	1.90	.....	6.72	.....	1.56	1.61	1.60	.....	10.09	1.62	5.60	1.50
31	1.80	.....	5.41	.....	1.45	.....	1.90	1.42	.....	1.62	.....	1.55

a No observation.

Roanoke River at Roanoke, Virginia.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.80	0.70	1.95	0.75	2.00	17	1.55	0.80	0.60	0.75	1.40	0.90
2	.....	.90	.65	1.70	.75	1.90	18	1.50	.69	.59	.75	1.30	.95
3	.....	.90	.60	1.40	.75	1.90	19	1.45	.62	.50	.75	1.22	.90
4	.....	.90	.72	1.10	.75	.85	20	1.40	.62	.55	.75	1.10	.85
5	.....	.90	.78	1.00	2.60	.82	21	1.40	.60	.60	.75	1.00	.85
6	.....	.85	.80	.95	2.10	.82	22	1.38	.65	.55	.75	.90	.85
7	.....	.70	.75	.90	1.95	.80	23	1.50	.75	.50	.75	.85	.82
8	.....	.70	.70	.85	1.95	.80	24	1.33	1.03	.50	.75	85	.82
9	.....	.70	.70	.85	1.90	.78	25	1.30	.99	.45	.75	.80	.80
10	3.53	.70	.55	.80	1.85	.78	26	1.25	.81	.50	.75	.75	.80
11	2.80	.90	.50	.80	1.82	.76	27	1.20	.75	.50	.75	1.00	.80
12	2.20	.80	.60	.75	1.80	.75	28	1.20	.75	.55	.75	1.30	.80
13	1.95	.70	.50	.80	1.70	.75	29	1.18	.75	1.33	.75	2.80	.80
14	1.75	.75	.55	.85	1.65	.75	30	.75	.60	3.40	.75	2.45	.75
15	1.63	.80	.52	.80	1.50	.75	31	.85	.75	.....	.75	.....	.75
16	1.53	.74	.65	.75	1.45	.75							

James River at Buchanan, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.30	1.30	7.85	—0.60	0.60	0.60	1.00	0.10	5.30	—0.20	4.40
2	.....	1.30	1.30	7.65	— .60	.60	.40	1.50	.00	2.60	— .20	3.15
3	.....	3.25	1.30	5.05	+1.30	.50	.30	1.30	—.10	1.65	— .20	2.40
4	.....	5.60	1.30	3.85	1.55	.50	.30	1.05	—.10	1.25	— .20	1.85
5	.....	3.90	1.30	2.90	1.05	.35	.30	.90	—.20	.85	+4.10	1.65
6	.....	3.80	1.30	2.40	.70	.10	.30	.50	—.20	.65	7.20	1.50
7	.....	6.05	1.30	2.15	.70	.10	.85	.35	—.20	.50	3.20	1.40
8	.....	4.35	1.30	1.85	.60	.90	1.00	.40	—.20	.50	2.35	1.25
9	.....	3.60	1.30	1.65	.50	1.30	10.25	.25	—.30	.40	1.70	1.20
10	.....	3.50	1.30	1.35	.30	1.10	6.85	.90	—.30	.30	1.40	1.10
11	.....	2.95	1.30	1.30	.30	1.05	3.55	.55	—.30	.30	1.15	1.00
12	.....	2.30	1.30	.50	.20	.70	2.40	.20	—.30	.15	.90	.90
13	.....	2.05	1.60	.40	.20	.45	2.45	.10	—.30	.10	.80	.90
14	.....	3.90	1.60	.15	.10	.35	1.90	.10	—.30	.10	.80	.80
15	.....	4.30	1.60	.10	.10	.30	1.40	.45	—.30	.10	.80	.70
16	.....	3.30	1.60	.10	.10	.30	1.10	.60	—.30	.10	.70	.60
17	.....	2.90	5.95	.10	.00	.30	1.00	.25	—.30	.10	.70	.50
18	.....	2.30	5.45	—.45	.00	.30	.90	.15	—.30	.10	.60	.50
19	.....	2.00	4.50	—.20	.00	.35	.80	.10	—.30	.00	.60	.50
20	.....	2.00	6.25	+.05	.00	.70	.55	.10	—.30	.00	.50	.50
21	.....	2.00	5.05	.10	.85	.65	.40	—.10	—.30	.00	.50	.40
22	.....	2.00	3.80	.10	1.15	.45	.40	+.50	—.30	—.10	.40	.40
23	.....	2.00	3.25	.10	.80	.30	.75	.45	—.30	—.10	.40	.40
24	.....	1.60	3.75	.10	.90	.20	.55	.20	—.30	—.20	.40	.40
25	4.80	1.35	3.90	.10	.90	.20	.40	.20	—.30	—.20	.40	.40
26	3.40	1.30	3.55	—.30	.75	1.80	.30	.35	—.30	—.20	.40	.30
27	2.60	1.30	3.40	—.60	.65	2.05	.20	.20	—.30	—.20	.40	.30
28	2.00	1.30	3.40	—.60	.75	1.45	.20	.20	—.30	—.20	.30	.20
29	1.65	1.30	3.55	—.60	.70	1.15	.20	.20	—.30	—.20	1.30	.20
30	1.50	.....	9.45	—.60	.60	1.85	.70	.20	12.30	—.20	5.35	.20
31	1.30	.....	8.80	.....	.60	.....	.70	.10	.....	.....	.....	.20

Dan River at Clarksville, Virginia.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	9.47	2.62	1.22	1.02	0.92	0.42	7.92	0.97	3.53
2	.....	.....	10.37	3.67	1.17	.92	.87	.40	8.97	1.02	4.82
3	.....	.....	9.52	4.42	1.07	.87	.82	.52	3.47	1.04	3.65
4	.....	.....	5.77	3.47	.97	.82	.77	1.37	1.72	1.47	2.55
5	.....	.....	3.99	2.38	1.47	.87	.75	1.52	1.47	2.62	2.17
6	.....	.....	3.37	2.26	2.12	1.02	.72	.97	1.32	6.92	2.05
7	8.95	.....	3.32	2.12	1.97	4.02	.70	2.97	1.25	4.97	1.97
8	7.42	.....	2.97	1.97	1.47	6.02	.67	1.82	1.17	2.47	1.89
9	5.75	.....	2.77	1.82	1.47	9.12	.65	1.47	1.07	2.17	1.80
10	5.42	.....	2.52	1.72	1.97	13.97	.65	.97	1.02	1.77	1.72
11	4.40	.....	2.51	1.67	1.82	14.07	.87	.82	1.02	1.57	1.62
12	3.42	.....	2.50	1.62	1.72	8.87	1.65	.62	.97	1.47	1.56
13	2.92	.....	2.45	1.57	1.67	5.62	1.77	.57	.95	1.57	1.51
14	3.70	.....	2.22	1.54	1.62	3.22	1.92	.55	.95	1.52	1.43
15	3.47	1.90	2.17	1.47	1.62	2.67	1.97	.57	1.02	1.50	1.53
16	3.32	1.87	2.12	1.02	1.60	2.47	2.12	.57	.97	1.48	1.72
17	2.97	2.45	2.07	.97	1.57	2.39	1.47	.62	.96	1.48	2.15
18	2.40	2.68	2.02	1.02	1.47	2.27	.97	.59	.92	1.25	1.97
19	2.22	2.80	1.97	1.12	1.37	2.17	.72	.57	.87	1.22	1.72
20	2.07	4.09	1.92	1.62	1.32	2.03	.67	.67	.87	1.19	1.65
21	1.92	4.52	1.85	2.18	1.47	1.85	.65	.92	.55	1.16	1.59
22	1.77	3.32	1.90	3.07	1.57	1.79	.62	1.47	.82	1.16	1.52
23	1.97	2.72	1.90	4.37	1.72	1.70	.62	1.75	.89	1.15	1.45
24	2.10	2.49	1.82	3.17	2.47	1.57	.62	.72	.92	1.14	1.39
25	2.17	2.72	1.90	2.17	3.02	1.42	.59	.57	.97	1.13	1.35
26	2.07	2.80	2.47	1.50	3.53	1.35	.67	.52	.94	1.12	1.31
27	1.96	2.47	2.40	2.32	3.67	1.17	.77	.47	.92	1.11	1.29
28	1.99	2.27	2.00	2.97	2.67	1.12	.62	.45	.92	1.10	1.27
29	2.17	2.27	1.90	2.32	2.02	1.07	.57	1.72	.92	1.32	1.24
30	.....	3.39	1.77	1.82	1.52	1.02	.47	5.47	.91	2.02	1.22
31	.....	7.89	.....	1.27	.....	.97	.42	.....	.94	.....	1.22

Staunton River at Clarksville, Virginia.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	8.94	2.09	0.69	0.49	0.39	—0.11	7.45	0.44	3.01
2	.....	.....	9.84	3.14	.61	.39	.34	— .11	8.50	.49	4.31
3	.....	.....	8.99	3.89	.54	.34	.29	— .01	2.96	.51	3.14
4	.....	.....	5.24	2.94	.44	.29	.24	+ .84	1.20	.94	2.03
5	.....	.....	3.46	1.85	.94	.34	.22	.99	.94	2.10	1.65
6	.....	.....	2.84	1.73	1.50	.49	.19	.44	.79	6.42	1.53
7	8.42	.....	2.79	1.59	1.44	4.54	.17	2.47	.72	2.37	1.45
8	6.89	.....	2.44	1.44	.94	6.84	.14	1.30	.64	1.95	1.37
9	5.16	.....	2.24	1.29	.94	10.54	.12	.94	.54	1.54	1.27
10	4.84	.....	1.99	1.19	1.44	13.94	.12	.44	.49	1.24	1.19
11	3.85	.....	1.98	1.14	1.29	13.44	.34	.29	.49	1.04	1.09
12	2.80	.....	1.97	1.09	1.19	8.39	1.12	.09	.44	.94	1.03
13	2.37	.....	1.92	1.04	1.14	5.14	1.24	.04	.42	1.04	.98
14	3.16	.....	1.60	1.01	1.09	2.74	1.39	.02	.42	.99	.92
15	2.94	1.37	1.64	.94	1.09	2.06	1.44	.04	.49	.98	1.03
16	2.78	1.33	1.59	.49	1.07	1.94	1.64	.04	.44	.95	1.20
17	2.41	1.92	1.54	.44	1.04	1.86	.97	.09	.43	.94	1.63
18	1.86	2.15	1.49	.49	.94	1.74	.46	.06	.39	.72	1.35
19	1.68	2.27	1.44	.59	.84	1.64	.20	.04	.34	.69	1.20
20	1.53	3.56	1.39	1.09	.79	1.44	.14	.16	.34	.66	1.13
21	1.38	3.99	1.32	1.65	.94	1.32	.12	.40	.32	.63	1.07
22	1.33	2.79	1.37	2.59	1.04	1.26	.09	.96	.29	.63	.90
23	1.43	2.19	1.37	3.84	1.19	1.27	.09	1.24	.36	.62	.92
24	1.56	1.96	1.29	2.64	1.94	1.04	.09	.19	.39	.61	.86
25	1.64	2.19	1.37	1.64	2.49	.89	.06	.04	.44	.60	82
26	1.54	2.27	1.94	.97	2.94	.82	.14	— .01	.41	.59	.78
27	1.43	1.96	1.86	1.79	3.14	.64	.24	—1.06	.39	.58	.76
28	1.46	1.72	1.47	2.44	1.14	.59	.09	— .08	.39	.57	.74
29	1.54	1.73	1.37	1.79	.49	.54	.04	+1.20	.39	.79	.71
30	.....	2.86	1.24	1.29	— .01	.49	— .06	4.99	.38	1.50	.69
31	.....	7.36	.....	.74	.....	.44	— .11	.....	.41	.....	.69

Roanoke River[1] *at Clarksville, Virginia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.1	.....	2.6	1.0	1.6	1.4	2.0	1.5	9.0	2.2	2.1	1.9
2	3.9	.....	2.3	1.0	1.5	1.7	1.9	1.7	11.3	2.8	2.0	1.8
3	2.7	.....	3.0	1.0	9.0	1.5	2.0	2.0	9.0	2.5	1.9	2.0
4	2.0	.....	3.2	1.0	13.0	1.5	1.6	2.8	3.8	7.7	1.9	2.5
5	1.5	.....	3.3	1.4	12.5	1.5	1.5	2.0	2.8	8.0	1.9	2.4
6	1.1	.....	2.5	1.3	4.5	1.5	1.0	.8	1.9	4.5	1.8	2.4
7	1.1	.....	2.2	1.2	4.2	1.6	.7	.5	1.5	2.6	1.8	2.3
8	1.0	1.8	2.0	1.1	2.8	1.4	.6	.4	1.5	2.2	2.0	2.3
9	1.0	1.6	2.2	1.0	2.5	1.0	.8	.2	1.4	1.9	1.9	2.2
10	1.0	4.5	2.0	1.0	2.2	.9	1.0	.1	3.0	1.7	1.8	2.0
11	1.0	7.4	2.0	1.0	2.0	.8	.6	.1	6.5	1.6	1.8	1.9
12	1.0	7.8	1.9	1.0	1.7	.7	.5	.1	9.0	1.5	1.7	1.8
13	1.0	9.0	1.8	1.0	1.6	.9	.4	.3	11.0	6.0	1.6	1.7
14	1.0	10.5	2.0	1.3	1.5	2.2	.4	.3	13.5	8.8	1.7	1.6
15	1.0	6.5	1.8	1.3	1.8	4.4	.4	.2	11.1	8.7	2.0	1.6
16	1.0	4.5	1.6	1.1	3.0	3.0	.4	.1	3.5	4.0	2.0	3.6
17	2.5	7.7	1.5	1.1	1.9	2.1	.3	.0	2.5	2.8	1.8	3.5
18	3.0	9.0	1.5	1.0	1.5	1.9	.5	.0	2.1	2.3	1.6	2.4
19	.....	7.4	1.4	1.0	1.3	1.7	.5	.1	1.9	2.0	1.6	2.1
20	.....	5.0	1.4	1.0	1.1	1.2	.3	.0	1.7	1.8	1.5	1.9
21	.....	3.0	1.4	.9	1.1	1.0	.8	— .1	1.6	7.3	1.7	1.8
22	.....	2.7	1.4	.9	1.1	1.0	.5	— .3	1.4	9.9	1.8	1.6
23	.....	2.5	1.3	.9	1.1	1.6	.4	.0	1.4	10.1	1.8	1.6
24	.....	2.2	1.3	.9	1.1	1.1	.3	+2.5	1.3	10.5	1.6	1.5
25	.....	2.0	1.3	.9	1.0	.9	.2	1.0	1.2	5.8	1.5	1.5
26	.....	1.9	1.3	1.0	1.0	.8	.1	.7	4.0	3.8	1.5	1.5
27	.....	1.8	1.3	2.7	1.0	.8	.1	.6	3.5	3.3	1.6	1.4
28	.....	2.4	1.2	2.8	1.9	.7	.1	5.0	2.6	3.0	3.2	1.4
29	.....	.....	1.2	2.3	2.8	1.3	0.0	9.0	1.8	2.7	3.0	1.4
30	.....	.....	1.2	2.0	2.1	2.6	— .1	11.0	1.5	2.4	2.2	2.1
31	.....	.....	1.2	.....	1.6	.....	+ .5	7.6	.....	2.3	.....	2.2

[1] Record kept by United States Weather Bureau.

Roanoke River[1] at Clarksville, Virginia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	1.8	2.4	5.4	1.7	1.3	1.1	1.1	1.3
2	1.7	2.0	5.8	1.7	1.3	1.0	2.1	1.5
3	1.6	4.4	5.4	1.7	1.3	.9	2.0	1.7
4	1.5	7.0	4.0	1.6	2.0	.8	1.8	1.3
5	1.5	6.9	3.2	1.5	3.1	.8	1.0	1.2
6	1.8	3.4	3.0	1.5	3.4	.8	.9	.7
7	3.2	3.0	2.8	1.4	2.2	.8	1.2	.5
8	3.1	3.2	2.6	1.4	1.6	1.0	1.1	.3
9	2.8	3.5	2.4	1.4	1.4	1.0	.6	.3
10	2.7	3.4	2.3	2.0	1.3	.8	.4	.5
11	3.3	2.6	2.2	2.3	1.2	.7	.4	.7
12	3.0	4.0	2.1	2.0	1.3	.7	.3	1.1
13	2.5	6.2	2.0	1.7	1.3	.6	.3	1.0
14	2.1	6.2	1.9	1.5	1.2	.6	.2	.8
15	2.0	5.6	1.8	1.5	1.1	.6	.2	1.1
16	1.9	4.5	1.8	1.4	1.1	.5	.2	.9
17	1.8	3.5	2.0	1.4	1.1	.5	.2	.8
18	1.7	2.9	2.1	1.4	1.3	.6	0.0	.7
19	1.6	2.7	2.1	1.4	2.0	.7	— .2	.5
20	1.6	2.4	1.9	1.4	4.6	.9	— .1	.4
21	1.6	2.9	1.9	2.0	2.4	.8	+ .3	.3
22	1.7	3.1	1.9	1.8	1.7	.7	.9	.2
23	1.7	2.8	1.8	1.5	1.5	.6	2.0	.1
24	1.7	2.4	1.9	1.4	1.5	.6	1.5	.1
25	1.6	2.4	2.0	1.3	1.4	.6	.9	.1
26	1.7	2.8	1.9	1.3	1.2	.5	.7	1.6
27	1.7	4.3	1.7	1.2	1.1	.5	.6	1.4
28	1.9	4.7	1.6	1.2	1.1	.6	.5	.7
29	4.0	.....	1.7	1.4	1.1	.7	.5	.5
30	4.1	.....	1.7	1.3	1.1	.9	1.1	.4
31	3.3	.....	1.6	.....	1.2	.....	1.3	.3

Roanoke River[1] at Clarksville, Virginia, for 1895.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Day.	Mar.	Apr.	May.	June.	July.	Aug.
1	4.0	1.7	5.9	1.5	2.5	0.8	17	2.5	3.0	2.0	1.3	1.6	1.0
2	6.7	1.8	4.7	1.4	3.5	.7	18	2.2	3.5	2.7	1.2	1.1	1.4
3	9.0	2.0	3.5	1.3	2.7	.7	19	2.1	2.8	2.1	1.1	.8	1.3
4	4.4	1.8	3.0	1.2	1.7	.6	20	4.0	2.0	2.2	1.1	.8	1.0
5	3.1	1.5	2.5	1.4	1.1	6	21	5.9	1.9	3.0	.9	.9	1.4
6	2.5	1.5	2.2	1.7	.9	.9	22	4.3	1.8	4.2	.9	.9	1.2
7	3.2	3.9	2.4	2.0	.9	1.0	23	3.5	1.7	3.0	.9	1.3	1.0
8	4.7	8.7	2.7	1.3	.9	.9	24	3.1	1.6	2.5	.9	1.5	.7
9	3.3	9.6	2.1	1.2	1.0	.9	25	2.6	1.5	2.9	1.0	3.3	.6
10	2.5	4.5	1.9	1.2	1.1	1.4	26	2.5	1.5	5.0	1.2	4.4	.6
11	2.6	2.9	1.8	1.4	1.2	1.0	27	2.3	7.4	4.0	2 0	2.5	.7
12	2.7	2.6	2.6	1.6	1.0	.8	28	2.1	6.5	2.5	1.8	1.8	.6
13	3.1	2.5	2.2	1.7	.9	.9	29	1.9	7.7	2.1	1.5	1.0	.6
14	3.4	2.3	1.9	1.8	.9	.8	30	1.7	7.9	1.8	1.2	.9	.5
15	3.2	2.1	1.6	1.6	1.1	.7	31	1.6	.....	1.7	.....	.9	.5
16	2.9	2.0	1.5	1.4	2.4	.6							

[1] Record kept by United States Weather Bureau.

Roanoke River[1] *at Clarksville, Virginia, for 1896.*

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	2.0	9.0	3.8	1.3	0.8	0.7
2	.....	1.5	9.1	3.7	1.0	.8	.7
3	.....	1.3	4.5	3.3	.9	.7	.7
4	.....	1.2	3.3	2.5	1.2	.7	.6
5	.....	1.1	2.5	1.8	2.0	2.7	.6
6	.....	1.0	2.3	1.5	1.5	4.3	.6
7	7.4	1.0	2.0	1.3	1.4	5.0	.5
8	7.5	1.0	1.9	1.2	1.3	8.0	.5
9	5.0	1.0	1.8	1.1	1.8	12.5	.5
10	.....	1.0	1.8	1.0	1.5	13.8	.4
11	.....	1.0	1.6	1.0	1.3	11.0	1.4
12	.....	1.5	1.5	.9	1.2	5.5	.7
13	.....	1.4	1.4	.9	1.5	4.0	.6
14	.....	1.3	1.4	.8	1.3	2.7	.5
15	.....	1.2	1.4	.8	1.2	2.4	.5
16	.....	1.6	1.4	.8	1.3	2.2	2.0
17	.....	1.7	1.3	.8	1.5	2.5	1.0
18	.....	2.0	1.3	.8	1.4	1.8	.9
19	.....	3.0	1.3	.8	1.2	1.4	.7
20	.....	3.9	1.3	2.7	1.2	1.3	.5
21	.....	2.7	1.2	3.5	1.1	1.2	.5
22	.....	2.0	1.2	2.9	1.8	1.2	.5
23	.....	1.8	1.2	2.5	1.6	1.0	.5
24	.....	1.9	1.2	1.9	1.5	1.0	.5
25	.....	1.9	2.0	1.5	1.9	1.0	.5
26	.....	1.9	1.8	1.8	3.0	.9	.4
27	.....	1.8	1.4	1.6	2.6	.9	.4
28	.....	1.8	1.2	1.5	2.4	.8	.4
29	.....	2.5	1.1	1.5	2.1	.8	.4
30	.....	4.0	4.8	1.5	1.3	.8	.4
31	.....	7.8	.....	1.5	.....	.8	.4

Roanoke River at Neal, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.56	1.65	2.80	2.60	5.40	17	.....	3.50	4.30	3.60	6.20	13.30
2	.....	3.90	1.30	a21.80	2.50	15.85	18	.....	2.70	4.64	3.40	5.80	13.30
3	.....	4.15	1.00	23.00	2.40	19.70	19	.....	5.30	3.50	3.10	5.12	11.70
4	.....	3.70	1.00	25.10	2.40	17.70	20	.....	5.20	2.50	2.90	4.70	10.00
5	.....	3.40	1.24	24.20	2.90	14.80	21	.....	3.90	2.80	2.70	4.40	8.80
6	.....	3.00	1.30	20.80	3.10	12.50	22	.....	2.90	2.60	2.50	4.20	7.80
7	.....	2.90	1.30	17.00	17.00	11.00	23	.....	2.40	2.80	2.40	4.00	7.00
8	.....	2.80	5.05	13.70	20.30	10.30	24	.....	2.00	3.30	2.50	3.80	6.40
9	.....	2.50	8.90	11.10	18.50	9.90	25	.....	2.03	3.30	2.60	3.70	5.90
10	.....	2.20	7.30	8.90	14.90	9.20	26	.....	2.25	2.60	2.60	3.60	5.40
11	.....	2.10	5.00	7.10	11.80	8.40	27	7.05	2.50	8.10	2.70	3.60	5.00
12	.....	2.30	3.30	5.60	9.70	7.60	28	5.09	2.20	1.80	2.70	3.50	4.60
13	.....	2.90	2.20	4.50	8.20	6.90	29	4.08	2.90	1.60	2.80	3.50	4.10
14	.....	5.20	1.80	4.20	7.10	6.30	30	4.24	2.70	1.90	2.72	3.80	3.90
15	.....	5.60	1.56	4.10	6.30	6.00	31	3.80	2.20	.....	2.60	.....	4.00
16	.....	4.60	2.10	3.80	6.10	8.30							

a Rise began about 10 a. m. and continued at rate of about 2 feet per hour for some time.

Tar River at Tarboro, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.30	1.00	2.82	0.89	3.87	17	.....	1.25	4.50	1.98	2.45	12.73
2	.....	1.00	.60	3.55	.96	4.34	18	.....	1.28	4.35	1.50	1.95	13.82
3	.....	.90	.45	4.20	1.20	4.85	19	.....	1.00	4.20	1.00	1.63	14.50
4	.....	1.20	.80	2.95	1.05	4.90	20	.....	.73	4.60	1.15	1.61	13.50
5	.....	1.46	.51	2.18	1.07	4.50	21	.....	.50	3.52	.90	1.50	12.20
6	.....	3.48	.30	1.90	2.15	4.70	22	.....	.65	2.10	.81	1.42	10.40
7	.....	2.87	.35	1.50	2.76	5.00	23	.....	.62	5.85	.69	1.30	8.20
8	.....	1.95	.60	1.20	3.72	5.80	24	.....	.65	7.30	.85	1.44	6.44
9	.....	1.45	.35	1.05	3.13	6.50	25	.....	.70	6.40	1.28	1.12	5.40
10	.....	1.00	.23	.85	2.59	6.72	26	3.56	1.20	4.60	1.12	1.05	4.75
11	.....	.82	.20	.90	2.10	6.10	27	3.00	1.30	3.60	1.32	1.02	4.20
12	.....	.50	.22	.81	1.71	5.33	28	2.68	1.40	2.85	1.00	1.00	4.05
13	.....	1.78	.12	1.05	2.62	4.64	29	2.25	1.60	2.58	.89	1.02	3.80
14	.....	1.92	.10	1.42	4.05	4.07	30	2.00	1.48	2.72	.80	1.45	3.50
15	.....	1.85	.18	1.70	3.20	3.98	31	1.76	1.10	.....	.58	.....	3.20
16	.....	1.53	3.45	2.00	2.62	9.75							

[1] Record kept by United States Weather Bureau.

Neuse River at Selma, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.00	0.30	5.00	0.60	3.70	17	.....	0.90	0.06	0.50	0.70	9.00
2	.....	2.00	.30	7.20	.60	3.50	18	.....	.90	.05	.40	.70	8.60
3	.....	2.00	.35	2.30	.60	3.00	19	.....	1.10	.00	.40	.60	5.50
4	.....	1.90	.40	.90	.40	2.80	20	.....	1.00	.00	.30	.60	4.60
5	.....	1.20	.30	.50	1.20	2.60	21	.....	1.00	1.04	.40	.60	3.50
6	.....	1.00	.30	.50	4.80	2.50	22	.....	.50	.04	.60	.50	3.00
7	.....	1.00	.30	.30	4.40	3.00	23	.....	.40	5.04	.90	.50	2.80
8	.....	1.00	.60	.20	2.30	4.00	24	.....	.50	1.07	.70	.50	2.00
9	.....	.90	.50	.20	1.50	3.80	25	.....	2.10	.07	.50	.50	1.90
10	.....	5.05	.30	.10	1.20	3.50	26	.....	2.00	.07	.40	.50	1.80
11	.....	5.50	.20	.20	.80	2.60	27	.....	1.10	.40	.30	.50	1.50
12	.....	5.50	.20	.50	.80	2.00	28	.....	1.00	.30	.30	.50	1.50
13	.....	2.25	.01	.70	1.30	2.00	29	1.10	1.00	.10	.30	.50	1.40
14	.....	1.50	.01	1.70	1.20	2.00	30	1.00	.50	1.50	.40	.70	1.30
15	.....	1.20	.01	1.00	.90	3.00	31	1.00	.30	.....	.40	.....	1.20
16	.....	.80	.01	.60	.80	7.30							

Cape Fear River at Fayetteville, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	18.00	6.50	9.00	7.50	3.70	4.00	7.00	3.30	1.30	31.00	2.50	6.00
2	18.90	6.50	10.40	9.50	5.00	3.20	5.30	4.30	1.10	26.80	2.70	15.40
3	11.40	7.90	9.30	22.50	8.00	2.70	4.00	4.00	1.00	19.50	2.70	14.00
4	8.00	27.70	7.60	19.40	12.80	4.00	3.50	3.30	.80	12.90	3.00	12.40
5	6.50	31.00	6.80	13.00	10.40	19.00	3.50	3.00	1.50	7.80	4.30	10.40
6	5.70	30.00	6.00	9.80	8.30	20.00	5.90	3.00	3.00	4.90	17.00	9.50
7	4.60	45.40	5.80	8.00	6.00	14.00	4.40	2.80	8.50	4.20	19.00	9.60
8	4.40	48.00	5.80	6.80	4.50	10.00	15.00	2.60	9.50	3.60	14.30	13.50
9	4.60	45.00	5.40	6.00	4.40	8.00	34.80	2.30	5.50	3.20	10.40	14.50
10	4.60	42.40	5.40	5.40	3.90	6.20	47.50	2.00	4.00	3.00	7.70	13.60
11	4.70	36.00	5.50	5.20	3.50	6.00	49.50	2.00	3.30	2.70	6.00	11.70
12	4.40	30.40	7.80	5.50	3.20	6.00	47.00	1.90	2.50	2.70	4.80	9.50
13	4.20	19.00	11.00	5.50	2.80	5.00	41.00	2.70	2.00	2.70	4.60	8.20
14	4.00	16.20	10.00	5.00	2.80	7.00	30.30	4.00	1.50	3.00	4.50	7.00
15	4.10	17.40	8.60	4.90	2.60	10.90	19.00	3.40	1.40	3.30	4.50	7.50
16	4.00	16.00	7.20	5.00	2.50	8.50	14.40	3.70	1.20	3.20	4.80	9.40
17	5.00	13.40	7.50	4.90	2.50	5.70	9.50	3.70	1.00	3.00	4.20	14.00
18	9.60	11.00	8.00	4.70	2.10	4.60	9.30	3.00	1.50	2.90	4.00	12.30
19	6.00	10.50	7.80	4.50	2.40	6.00	9.00	2.60	1.90	2.60	4.00	9.00
20	1.40	10.60	8.50	4.20	2.30	5.30	8.70	2.50	3.00	2.40	3.80	9.00
21	15.00	9.80	10.50	4.00	3.50	6.40	8.90	2.50	2.50	2.10	3.60	8.20
22	22.20	9.00	9.60	3.80	4.10	5.00	8.30	2.10	1.50	2.20	3.50	7.00
23	20.00	8.00	7.80	3.60	8.17	4.30	7.90	2.70	6.00	2.30	3.20	6.90
24	15.00	7.80	6.80	3.50	11.40	4.50	7.20	2.00	6.80	2.70	3.10	6.30
25	15.60	7.80	6.50	4.00	17.40	6.40	7.50	2.40	5.00	4.40	3.00	5.40
26	11.00	7.70	6.60	4.60	12.00	7.80	7.00	4.00	3.90	4.10	3.00	4.60
27	26.20	7.40	7.00	7.00	9.50	8.60	5.20	3.70	3.20	3.50	3.00	5.00
28	22.00	7.30	6.30	5.50	8.00	6.00	4.30	2.70	2.90	3.00	3.30	4.90
29	29.40	7.90	6.20	4.90	7.20	10.80	3.70	2.00	3.50	2.80	3.20	4.80
30	18.10	.....	5.80	4.10	6.00	8.90	3.60	1.90	8.00	2.50	3.50	4.90
31	17.00	.....	5.30	.....	5.00	.....	3.40	1 40	.....	2.50	.....	5.00

Yadkin River at Norwood, North Carolina.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	1.00	7.40	1.30	1.50	12	1.20	1.20	1.70	1.70	23	1.20	1.20	1.40	1.80
2	1.00	3.40	1.30	2.70	13	1.20	1.20	2.20	1.30	24	1.30	1.20	1.40	1.80
3	1.00	2.80	1.30	2.70	14	1.20	1.20	1.30	1.60	25	1.20	1.30	1.40	1.70
4	.90	1.80	1.40	2.30	15	1.30	1.30	1.90	1.90	26	1.20	1.30	1.40	1.70
5	.90	1.60	3.10	2.30	16	1.20	1.30	1.70	2.50	27	1.10	1.30	1.40	1.70
6	2.50	1.50	6.00	2.20	17	1.30	1.20	1.60	3.80	28	1.00	1.30	1.40	1.70
7	3.30	1.40	3.40	2.30	18	1.30	1.20	1.50	2.90	29	1.20	1.20	1.50	1.60
8	2.10	1.40	2.50	2.40	19	1.20	1.20	1.50	2.30	30	1.30	1.20	1.70	1.60
9	1.65	1.30	2.20	2.20	20	1.20	1.10	1.50	2.10	31	.....	1.20	.....	1.70
10	1.45	1.30	2.10	2.10	21	1.10	1.10	1.50	2.00	.....	.....	.....	.....	.....
11	1.30	1.20	1.90	1.90	22	1.10	1.10	1.50	1.90	.....	.....	.....	.....	.....

Yadkin River at Salisbury, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.60	2.00	2.50	2.50	1.80	1.50	1.80	2.00	1.40	8.40	1.68	6.70
2	3.00	2.00	2.20	8.00	1.80	1.50	1.60	1.90	1.40	3.70	1.70	4.10
3	2.40	5.70	2.70	7.30	2.10	1.80	1.60	1.90	1.40	2.20	1.72	3.70
4	2.20	6.70	1.80	4.00	2.90	3.90	2.60	1.70	1.40	2.50	.....	2.80
5	1.80	4.90	2.00	3.10	2.30	3.70	2.70	1.70	1.50	1.80	5.80	2.50
6	1.60	5.30	2.00	2.60	2.20	2.50	2.80	1.60	4.50	1.70	6.78	2.55
7	1.60	7.00	1.90	2.50	2.00	2.20	4.50	1.60	2.70	1.70	3.60	2.53
8	1.90	5.00	1.90	2.40	1.90	2.00	4.90	1.60	2.20	1.60	3.50	2.52
9	3.70	5.00	1.90	2.20	1.90	2.00	12.90	1.50	1.90	1.60	2.50	2.30
10	3.60	4.70	1.90	2.20	1.90	1.90	a15.00	2.00	1.60	1.60	2.30	2.27
11	3.40	3.60	2.00	2.20	1.90	2.20	10.00	2.00	1.50	1.60	2.20	2.26
12	2.60	3.00	2.20	2.10	1.90	1.80	9.80	1.90	1.50	1.62	2.10	2.26
13	2.10	2.70	2.40	2.00	1.80	1.80	7.90	1.80	2.00	1.66	2.15	2.25
14	1.70	3.30	2.10	2.00	1.70	1.80	4.90	1.60	1.75	1.64	2.00	2.23
15	1.70	3.10	2.00	2.00	1.70	1.70	4.00	1.60	1.60	1.70	2.00	2.30
16	1.70	2.80	1.80	2.00	1.70	1.60	3.70	2.50	1.50	1.70	2.00	5.00
17	1.90	2.50	2.00	2.00	1.70	1.60	2.80	2.20	1.60	1.68	1.98	3.55
18	2.20	2.30	2.00	2.00	1.70	1.80	2.40	2.90	1.60	1.65	1.95	3.40
19	2.10	2.20	1.90	2.10	1.60	1.80	2.40	2.70	1.60	1.50	1.92	2.95
20	2.00	2.10	2.20	2.00	1.60	1.80	2.20	2.50	1.50	1.50	1.90	3.90
21	1.90	2.00	2.60	2.00	1.50	1.70	2.20	1.90	1.50	1.50	1.90	3.70
22	1.80	1.80	2.20	2.00	1.80	1.70	2.30	1.90	1.50	1.48	1.90	3.33
23	2.50	2.10	2.10	2.00	1.80	1.60	2.50	1.50	1.70	1.48	1.89	2.30
24	4.30	2.20	2.10	1.90	1.80	1.80	2.30	1.50	1.60	1.60	1.88	2.20
25	3.70	2.10	2.50	1.90	1.70	2.10	2.20	1.50	1.50	1.76	1.88	2.13
26	3.20	2.10	2.40	2.00	2.00	2.80	2.00	1.60	1.50	1.67	1.88	2.12
27	2.60	2.10	2.20	2.00	2.00	2.60	1.90	1.60	1.46	1.65	1.90	2.10
28	2.40	2.20	2.10	1.90	1.80	2.20	1.90	1.50	1.45	1.65	1.90	2.00
29	2.20	2.30	2.00	1.90	1.70	2.10	2.20	1.50	1.50	1.65	2.70	2.00
30	2.10	.....	2.10	1.90	1.70	1.90	1.90	1.50	8.60	1.65	6.30	2.08
31	2.00	.....	2.60	.....	1.60	.....	1.90	1.40	.....	1.68	.....	2.07

a July 10 river rose 14.90 above low-water mark.

Catawba River at Rockhill, South Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.30	2.10	2.30	2.10	1.70	1.50	1.70	2.00	1.50	3.90	1.60	5.50
2	2.90	2.10	2.20	2.70	1.80	1.90	1.60	1.90	1.50	2.60	1.70	4.30
3	2.40	3.60	2.10	5.80	3.80	2.20	2.00	2.00	1.50	2.00	1.70	3.10
4	2.20	4.90	2.10	3.50	4.30	2.50	2.60	1.90	1.50	1.70	1.70	2.60
5	2.00	3.50	2.00	2.80	2.90	3.20	2.00	1.90	2.10	1.60	3.30	2.40
6	1.90	6.25	2.00	2.50	2.50	2.60	4.50	2.00	2.10	1.60	5.40	2.30
7	1.80	6.60	2.00	2.30	2.30	2.10	5.20	1.90	2.90	1.60	3.90	2.40
8	1.80	4.90	2.00	2.20	2.10	1.90	7.37	1.80	2.20	1.50	2.60	2.30
9	2.00	5.70	1.90	2.10	2.00	1.80	12.22	1.80	1.90	1.50	2.40	2.20
10	1.90	5.30	1.90	2.10	2.00	2.20	15.20	1.70	1.70	1.50	2.20	2.10
11	1.90	4.00	1.90	2.00	1.90	1.80	10.65	1.70	1.60	1.60	2.00	2.00
12	1.90	3.20	2.10	2.00	1.80	1.70	7.90	1.70	1.60	1.50	1.90	1.90
13	1.80	2.80	2.10	2.00	1.80	1.70	6.30	1.80	1.50	1.50	2.50	1.90
14	1.80	2.90	2.00	1.90	1.80	1.60	4.40	1.70	2.00	1.50	2.20	1.90
15	1.80	2.80	2.00	1.90	1.70	1.60	3.40	2.10	1.70	1.60	2.20	1.90
16	1.80	2.70	1.90	1.90	1.70	1.60	3.10	2.00	1.60	1.60	2.10	3.20
17	2.10	2.60	1.90	1.90	1.70	1.60	2.80	1.90	1.60	1.60	1.90	3.40
18	2.40	2.40	1.90	1.90	1.70	1.60	2.60	2.00	1.60	1.50	1.80	2.70
19	2.20	2.40	1.90	1.80	1.70	1.80	2.40	2.00	1.60	1.50	1.80	2.30
20	2.00	2.30	2.10	1.80	1.70	2.00	2.70	1.80	1.60	1.50	1.80	2.20
21	2.00	2.30	2.00	1.80	1.60	2.00	2.50	1.70	1.50	1.50	1.80	2.10
22	1.90	2.20	2.10	1.80	1.60	1.90	2.50	1.60	1.60	1.50	1.70	2.00
23	2.60	2.10	2.00	1.80	1.60	2.10	2.20	1.60	1.60	1.50	1.70	2.00
24	3.80	2.10	2.00	1.80	1.60	1.90	2.30	1.60	1.60	1.60	1.70	1.90
25	4.50	2.20	2.00	1.80	2.60	1.90	2.20	1.60	1.60	1.60	1.70	1.80
26	3.80	2.10	2.20	1.80	1.90	2.10	2.10	1.60	1.60	1.60	1.70	1.80
27	2.90	2.10	2.10	1.80	1.80	2.00	2.10	1.60	1.50	1.60	1.70	1.80
28	2.60	2.10	2.00	1.80	1.90	2.00	2.40	1.60	1.50	1.60	1.70	1.80
29	2.40	2.30	2.00	1.70	1.80	2.00	2.40	1.60	1.60	1.50	1.90	1.80
30	2.20	.....	1.90	1.70	1.70	1.90	2.30	1.50	4.30	1.50	2.20	1.80
31	2.20	.....	2.00	.....	1.60	.....	2.10	1.50	.....	1.60	.....	1.80

Catawba River at Catawba, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.25	1.65	2.45	1.68	5.58	17	2.98	2.08	1.82	1.48	1.92	3.28
2	.....	2.25	1.85	2.25	1.65	5.32	18	2.92	1.88	1.62	1.48	1.92	2.95
3	.....	2.22	1.48	1.92	1.58	3.32	19	2.78	1.82	1.52	1.48	1.92	2.95
4	3.05	2.28	1.45	1.65	1.88	2.65	20	2.75	1.68	1.53	1.48	1.92	2.42
5	2.95	2.15	3.32	1.52	7.38	2.65	21	2.62	1.68	1.52	1.58	1.92	2.22
6	4.32	2.05	2.32	1.58	3.92	2.32	22	2.72	1.62	1.55	1.50	1.88	2.05
7	3.82	1.98	2.32	1.58	3.35	2.32	23	2.72	1.65	1.52	1.52	1.85	2.00
8	5.75	1.92	1.72	1.55	2.32	2.18	24	2.62	1.68	1.52	1.58	1.85	2.12
9	5.00	1.92	1.62	1.52	2.12	2.12	25	2.52	1.65	1.52	1.58	1.78	1.98
10	7.72	1.95	1.52	1.52	1.95	2.10	26	2.48	1.62	1.48	1.52	1.75	1.95
11	7.48	2.02	1.52	1.52	1.88	1.98	27	2.42	1.62	1.48	1.52	1.72	1.85
12	5.95	1.98	1.72	1.55	1.88	1.98	28	2.92	1.52	1.52	1.52	1.72	1.90
13	5.25	1.92	1.95	1.55	1.85	1.98	29	2.48	1.52	1.55	1.55	2.98	1.90
14	4.38	1.88	1.68	1.68	1.82	1.95	30	2.35	1.65	4.02	1.55	7.42	1.90
15	3.58	2.02	1.62	1.62	1.92	3.78	31	2.28	1.85	.....	1.68	.....	1.90
16	3.32	2.15	1.62	1.52	1.92	3.68							

Broad River at Gaffney, South Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.43	0.10	0.81	0.47	2.63	17	0.59	0.68	0.30	0.29	0.65	1.45
2	.....	.41	.11	.44	.28	1.60	18	.53	.49	.35	.23	.59	1.21
3	.....	.60	.84	.38	.40	1.02	19	.52	.30	.23	.20	.53	1.09
4	.....	.67	.46	.30	.40	.92	20	.51	.22	.10	.25	.72	1.12
5	.....	.38	.63	.22	1.50	1.50	21	.50	.28	.10	.29	.79	1.11
6	.....	.28	.49	.35	5.82	1.11	22	.50	.23	.30	.27	.60	1.05
7	.....	.32	.40	.31	2.40	1.15	23	.49	.20	.25	.29	.65	.99
8	.....	.30	.41	.30	1.98	1.10	24	.50	.18	.18	.28	.71	.94
9	.....	.18	.40	.25	.92	1.30	25	.48	.21	.14	.32	.69	.91
10	2.52	.30	.14	.30	.68	.91	26	.55	.24	.19	.28	.66	1.01
11	5.88	.25	.20	.22	.62	.85	27	.53	.17	.12	.31	.68	.80
12	1.60	.33	.82	.15	.31	.83	28	1.64	.18	.05	.35	.69	.93
13	.83	.22	.29	.31	.75	.77	29	.78	.20	.19	.29	.45	.95
14	.81	.48	.20	.35	1.04	.99	30	.62	.10	1.64	.31	1.70	.92
15	.78	.50	.23	.37	1.84	1.15	31	.48	.14	.....	.30	.....	.89
16	.83	.36	.20	.30	1.75	2.05							

Broad River at Alston, South Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.61	1.50	8.35	2.71	8.46	17	4.83	2.13	1.99	2.60	3.07	6.01
2	.....	3.02	1.85	3.95	2.63	7.80	18	4.03	2.86	1.09	1.96	2.89	4.39
3	2.21	3.03	1.93	3.45	2.20	6.55	19	3.87	2.52	2.05	1.95	2.73	4.06
4	2.17	2.95	2.73	2.52	2.40	6.00	20	5.00	2.35	2.01	1.75	2.74	3.80
5	2.87	2.86	4.75	2.21	9.47	5.33	21	5.42	3.67	1.93	1.90	2.76	3.55
6	2.64	2.61	4.93	1.90	13.38	5.21	22	4.06	2.81	2.78	2.02	2.60	3.50
7	8.20	2.51	3.89	1.85	10.33	5.84	23	3.84	1.98	4.63	2.03	2.69	3.45
8	13.39	2.48	3.21	2.15	7.20	6.77	24	3.80	1.95	2.68	2.40	2.56	3.40
9	16.24	2.30	2.52	2.10	4.11	6.35	25	3.14	2.05	2.51	2.64	2.72	3.25
10	17.26	2.03	2.18	2.00	3.56	5.61	26	2.90	2.01	1.94	2.49	2.66	3.15
11	13.59	1.91	2.13	2.05	2.73	4.40	27	2.87	2.15	1.85	2.07	2.62	3.04
12	13.39	2.87	2.15	1.81	3.15	3.96	28	2.79	2.19	1.85	2.25	2.70	3.06
13	9.92	2.07	2.36	1.72	5.11	3.64	29	4.77	2.44	2.11	2.20	2.75	3.09
14	6.55	2.92	2.51	2.02	4.78	3.70	30	3.40	2.15	8.78	2.19	4.26	3.18
15	5.05	2.71	1.96	2.20	3.85	3.40	31	2.90	1.65	.....	2.26	.....	3.07
16	4.20	3.31	2.15	2.40	3.31	6.30							

Saluda River at Waterloo, South Carolina.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.90	4.00	3.70	8.30	17	.....	3.15	2.80	4.65	5.55
2	.....	3.50	3.50	2.60	(a)	18	.....	3.15	3.15	4.55	4.75
3	.....	2.80	3.75	4.00	(a)	19	.....	3.70	2.20	4.50	5.15
4	.....	1.90	3.80	10.80	(a)	20	.....	3.00	3.20	4.45	4.15
5	.....	3.50	2.40	14.50	5.50	21	.....	2.20	3.15	4.45	4.35
6	.....	4.15	3.70	14.50	5.90	22	.....	4.25	3.00	3.80	4.65
7	.....	3.80	3.65	11.35	5.15	23	.....	4.35	3.60	3.80	4.00
8	.....	4.00	3.65	5.60	5.85	24	.....	4.00	4.10	4.30	4.55
9	.....	3.60	3.45	5.10	5.80	25	.....	3.30	3.90	4.35	3.85
10	.....	3.30	3.10	4.90	5.20	26	.....	3.20	2.45	4.25	3.20
11	.....	3.30	3.00	4.70	4.90	27	.....	2.90	3.80	4.30	2.85
12	.....	3.90	2.20	4.50	4.75	28	.....	2.30	3.80	4.25	3.80
13	.....	3.00	3.45	6.30	3.90	29	.....	5.40	3.55	5.20	4.35
14	.....	2.30	3.60	6.20	4.30	30	3.20	5.35	3.70	7.55	4.40
15	.....	3.65	3.60	4.85	8.40	31	2.20	.....	4.30	.....	4.35
16	.....	3.25	3.30	4.70	7.80						

a Ice on river; no readings December 2, 3, and 4.

Savannah River near Calhoun Falls, South Carolina.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.00	2.00	2.20	5.60	17	2.10	2.00	1.95	3.00	3.40
2	.....	1.90	1.95	2.15	5.00	18	2.05	1.95	1.90	2.90	3.10
3	.....	1.85	1.90	2.05	4.95	19	2.05	1.90	1.85	2.65	3.00
4	2.40	1.80	1.95	3.60	5.15	20	2.00	1.85	1.80	2.40	2.85
5	2.30	1.95	1.90	5.65	5.00	21	1.90	1.80	1.80	2.25	2.80
6	2.15	1.85	1.85	7.15	4.05	22	1.85	1.70	1.75	2.35	2.75
7	2.10	3.00	1.90	4.75	3.50	23	1.80	2.50	1.75	2.30	2.65
8	2.00	2.40	1.75	3.00	3.75	24	1.75	2.40	2.15	2.30	2.60
9	2.05	2.40	1.70	2.60	3.05	25	1.75	2.35	2.05	2.30	2.55
10	2.10	2.25	1.70	2.45	3.20	26	2.00	2.25	2.00	2.25	2.50
11	2.05	2.20	2.00	2.30	2.85	27	2.45	2.00	1.95	2.25	2.45
12	2.00	2.30	2.25	2.20	2.60	28	2.00	1.90	1.90	2.20	2.40
13	1.95	2.15	2.50	5.60	2.45	29	1.95	1.95	1.85	2.30	2.40
14	2.80	2.10	2.40	4.10	2.55	30	1.90	2.00	1.95	2.95	2.40
15	3.10	2.05	2.15	3.60	3.85	31	1.85	.....	2.10	.....	2.35
16	2.30	2.00	2.00	3.25	3.20						

Oconee River[1] *at Dublin, Georgia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.6	2.8	11.2	3.8	1.9	0.2	1.4	5.0	4.9	1.0	2.0	1.3
2	3.6	2.5	11.8	3.5	1.8	.1	.6	6.8	3.9	.8	2.4	1.2
3	3.0	2.3	12.4	3.4	1.8	.0	.6	7.5	2.9	.6	3.0	1.1
4	2.6	2.3	12.8	3.4	1.5	.1	1.0	6.5	1.4	.4	6.1	1.0
5	1.9	2.5	13.0	3.5	1.4	.1	.8	5.0	1.0	.2	7.6	2.0
6	1.8	2.7	12.7	3.8	1.3	.2	.5	8.0	1.3	.1	6.0	2.4
7	2.0	2.9	11.0	3.8	1.1	.2	1.1	9.4	1.4	.2	3.6	2.4
8	2.0	2.7	8.0	3.7	1.0	.3	.9	10.0	1.1	.2	2.7	2.1
9	2.6	2.3	6.5	3.1	.9	.4	.3	11.0	1.8	1.1	2.0	1.9
10	3.8	2.2	6.0	2.9	.9	.4	1.4	13.2	1.8	6.5	1.7	1.7
11	4.4	2.2	5.5	3.0	.9	.4	4.9	14.9	1.4	8.6	1.5	2.2
12	5.0	4.0	5.5	4.0	1.5	.5	4.8	13.6	1.4	9.8	1.4	3.4
13	6.0	6.6	7.5	4.8	1.1	.6	3.3	7.8	1.3	12.5	1.3	6.0
14	6.6	7.8	8.6	4.1	.9	.7	1.8	4.0	1.0	14.8	1.3	8.1
15	6.9	9.7	8.9	3.3	.9	.7	.9	3.8	.9	13.8	1.4	9.5
16	6.5	11.3	8.6	2.9	1.5	.7	.8	2.0	.8	8.4	1.6	11.4
17	4.9	12.3	6.9	2.6	2.9	.7	.7	1.4	.6	3.4	1.8	12.9
18	5.0	13.7	6.4	2.5	2.5	.6	.4	1.4	.9	2.6	1.8	13.0
19	4.9	14.9	6.4	2.5	2.0	.3	1.1	4.9	2.2	2.0	1.6	10.5
20	4.3	14.3	6.3	2.8	1.6	.4	.3	6.0	4.5	1.8	1.6	5.4
21	3.5	12.7	5.9	4.5	1.9	.2	3.7	5.1	6.1	1.6	1.4	3.8
22	3.0	10.3	5.0	5.0	2.0	.1	5.0	3.3	6.6	1.4	1.5	3.2
23	3.2	8.4	4.4	4.9	1.5	.4	4.4	2.9	4.7	1.1	1.6	2.9
24	3.8	7.8	4.4	4.0	1.2	.8	3.8	2.3	2.1	1.0	1.5	2.5
25	3.7	8.0	5.1	3.0	1.0	.4	4.4	2.1	1.4	1.0	1.7	2.3
26	3.5	9.6	6.2	2.5	1.0	1.0	4.6	2.8	1.0	1.0	1.7	2.2
27	4.0	10.2	6.9	2.3	.9	2.9	3.8	4.4	1.0	1.0	1.8	2.7
28	3.9	10.8	6.0	2.0	.6	1.5	3.4	4.2	1.0	.9	1.7	3.9
29	3.4	.....	5.3	1.9	.5	.9	4.4	4.8	1.0	.9	1.4	5.0
30	3.0	.....	4.5	1.9	.5	1.5	3.4	4.2	1.0	.8	1.4	5.3
31	2.9	.....	4.0	.....	.4	.....	3.0	5.0	.....	.8	.....	4.3

[1] Record from United States Weather Bureau.

Oconee River[1] at Dublin, Georgia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	3.4	14.2	5.4	5.2	9.6	6.8	2.5	0.9	2.3	0.3
2	3.2	14.5	5.2	5.0	10.3	4.4	5.0	.7	2.9	.3
3	3.2	14.8	5.0	5.2	10.5	3.6	6.5	.6	2.5	.2
4	3.5	14.2	6.8	5.8	8.7	3.0	6.9	.8	2.4	.1
5	3.8	13.4	7.8	5.7	6.6	2.8	6.4	6.5	5.7	.1
6	3.7	12.1	8.3	5.2	5.6	2.6	5.0	6.6	6.5	.0
7	3.4	11.3	8.5	4.6	5.2	2.4	3.8	4.0	7.0	.0
8	3.0	10.0	8.6	5.8	5.2	2.4	4.3	2.7	7.3	.1
9	3.0	9.2	9.9	8.4	4.9	3.0	7.4	3.5	8.3	.1
10	7.7	8.7	10.9	9.2	4.7	2.3	8.7	3.8	9.2	.1
11	10.4	7.8	12.0	10.3	6.4	2.1	9.5	2.9	7.5	.5
12	11.9	7.1	13.1	10.1	6.1	2.0	10.5	2.3	4.3	.4
13	15.5	7.8	13.1	10.2	6.0	1.9	11.4	2.0	4.8	.3
14	18.0	7.9	13.1	8.8	5.4	1.9	11.5	2.1	4.3	.2
15	17.9	7.9	15.4	6.0	4.4	2.3	7.6	3.3	3.2	.7
16	16.9	7.3	17.9	4.8	3.8	3.0	4.0	5 3	2.4	.6
17	15.5	7.4	20.2	4.8	3.4	2.6	3.2	6.1	2.2	.5
18	13.4	7.5	22.0	6.1	3.1	3.8	2.7	7.0	1.8	.4
19	10.1	7.7	23.4	7.4	3.3	5.7	2.4	7.5	1.8	.4
20	7.4	8.1	22.9	8.5	3.2	4.8	2.9	8.2	1.5	.3
21	6.1	8.5	21.6	9.8	3.5	2.9	2.5	9.5	1.4	.3
22	5.4	8.3	19.6	10.4	3.7	2.2	2.2	11.0	1.2	.3
23	5.0	8.0	17.2	9.7	4.7	1.9	2.0	12.0	1.0	.1
24	4.9	7.7	15.5	7.4	4.7	1.9	1.8	11.7	.9	.1
25	4.7	7.4	14.0	5.5	4.8	1.8	1.7	9.7	.8	.1
26	7.8	6.8	12.6	5.0	5.6	1.7	1.5	5.5	.6	.0
27	10.5	6.1	10.9	5.0	6.7	1.6	1.4	3.3	.5	.0
28	10.7	5.7	9.0	6.6	7.8	1.6	1.3	3.3	.4	.0
29	11.8	.....	7.5	7.8	8.4	2.5	1.2	3.9	.3	.0
30	13.2	.....	6.8	8.8	9.2	2.0	1.2	3.0	.3	.1
31	14.0	.....	5.6	.....	9.0	.....	1.0	2.4	.....	.1

Oconee River[1] at Dublin, Georgia, for 1896.

[No record was kept at this station from May to October, 1896. Capt. J. D. Roberts, in charge of the steamers Henry and Gipsy, states that from the 15th of September to the 15th of October, 1896, occurred the lowest water in six years, the gage at Dublin going down to —1.20 and remaining at about that level for nearly thirty days. This information is valuable and authentic.]

Day.	Jan.	Feb.	Mar.	Apr.	Oct.	Nov.	Dec.
1	4.1	6.0	6.6	3.0	.....	0.5	3.2
2	5.0	4.5	6.8	3.8	.....	.1	6.7
3	4.7	4.4	6.4	5.5	.....	.4	9.5
4	3.6	6.5	5.4	5.8	.....	1.1	10.7
5	2.8	6.4	5.0	5.0	.....	5.4	11.4
6	2.2	8.4	4.0	4.4	.....	7.7	12.8
7	1.9	11.0	3.8	3.5	.....	19.3	13.1
8	1.9	11.6	4.6	3.0	.....	10.5	12.4
9	2.7	14.8	6.4	2.8	.....	0.2	10.1
10	4.0	17.0	6.2	2.7	.....	7.5	7.3
11	4.0	16.8	5.8	2.6	.....	3.4	6.5
12	3.5	16.5	6.7	2.4	.....	2.5	5.6
13	3.0	15.9	7.3	2.3	.....	2.5	4.5
14	2.5	15.0	7.6	2.2	.....	3.6	4.1
15	2.3	13.4	7.0	2.1	.....	3.7	4.1
16	2.0	11.2	5.8	2.0	.....	3.9	4.0
17	3.5	9.6	5.2	1.9	1.1	3.5	8.0
18	6.7	8.7	4.8	1.8	1.1	2.5	8.9
19	7.5	6.7	4.6	1.7	1.1	1.7	9.7
20	8.0	5.8	4.4	1.7	1.2	1.5	8.1
21	8.0	5.2	4.7	1.6	1.2	1.3	5.3
22	6.4	4.8	4.6	1.4	1.2	1.1	4.1
23	5.0	4.6	4.3	1.2	1.2	1.0	3.7
24	6.9	4.2	4.1	1.0	1.2	.9	3.2
25	8.3	4.1	3.9	.9	1.1	.8	3.0
26	8.9	4.0	4.5	.9	.6	.6	2.8
27	10.0	4.0	4.4	1.1	.2	.5	2.5
28	11.4	3.9	4.2	1.1	.1	.6	2.3
29	12.3	5.0	3.9	1.5	.2	.6	2.3
30	12.0	.....	3.7	1.8	.4	.6	2.2
31	10.9	.....	3.3	.....	.6	.....	2.2

[1] Record from United States Weather Bureau.

Oconee River at Cary, Georgia.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1....	2.10	5.10	9...	1.80	2.90	17...	.....	2.40	25...	1.90	2.00
2....	1.90	4.80	10...	1.80	2.70	18...	.....	2.20	26...	1.90	2.10
3....	1.70	4.40	11...	1.80	2.60	19...	.....	2.40	27...	1.80	2.00
4....	2.10	4.20	12...	1.90	2.50	20...	.....	2.30	28...	1.90	1.90
5....	2.70	3.70	13...	1.80	2.40	21...	.....	2.20	29...	2.90	2.10
6....	2.30	3.40	14...	1.90	2.30	22...	.....	2.20	30...	3.90	2.00
7....	2.20	3.20	15...	1.90	4.00	23...	.....	2.10	31...	.....	2.00
8....	1.80	3.00	16...	2.00	2.80	24...	.....	2.00			

Ocmulgee River[1] *at Macon, Georgia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	.....	5.30	12.70	2.40	1.60	2.60	1.00	1.40	9.30	1.30	1.70	2.50
2.....	.....	4.80	10.00	2.30	1.40	2.40	1.10	1.80	8.70	1.30	1.60	3.00
3.....	.....	3.90	7.80	2.20	1.80	5.40	1.10	2.20	5 50	1.50	1.60	2.80
4.....	.....	3.10	12.70	2.10	6.70	6.80	1.80	1.80	3.00	8.00	1.60	2.70
5.....	.....	2.80	12.20	2.10	3.40	6.70	1.00	2.00	2.80	5.00	1.60	2.50
6.....	.....	3.40	9.50	2.30	3.10	5.10	1.00	6.20	2.40	3.50	1.60	3.20
7.....	.....	2.30	7.10	2.50	7.20	5.50	1.00	13.40	2.40	3.00	1.50	2.00
8.....	.....	1.80	6.50	2.20	4.90	9.70	1.00	9.50	2.30	2.80	1.50	1.80
9.....	.....	1.60	4.70	2.00	4.90	7.00	1.80	5.00	3.00	2.70	1.50	1.70
10.....	.....	1.30	8.90	1.80	3.40	3.40	1.20	3.20	4.00	2.60	1.50	1 60
11.....	.....	2.80	7.80	1.70	2.90	2.50	1.20	2.00	4.10	2.60	1.50	1.50
12.....	.....	4.60	5.80	1.70	2.20	2.20	1.20	1.80	5.40	2.50	1.50	1.50
13.....	.....	14.60	5.00	1.60	1.80	2.00	1.10	1.70	9.40	2 50	1.50	1.50
14.....	.....	13.00	4.10	1.60	1.60	3.00	1.10	1.70	10.90	2.80	1.50	1.50
15.....	.....	11.20	3.50	1.60	1.30	3.00	1.10	4.20	6.80	2.70	1.50	1.50
16.....	.....	11.00	2.60	1.70	1.20	3.00	.90	4.00	4.00	2.50	1.50	1.50
17.....	.....	13.40	3.00	1.60	1.50	2.00	.90	2.00	3.50	2.50	1.50	3.00
18.....	.....	12.00	2.40	1.40	1.20	1.80	1.00	1.90	2.00	2.50	1.50	2.80
19.....	.....	11.30	2.20	1.20	1.20	3.00	1.40	1.70	2.00	2.40	1 50	3.50
20.....	.....	10.60	2.10	2.50	1.00	2.60	1.60	1.60	1.60	2.20	1.50	3.20
21.....	2.70	6.80	.....	9.00	.80	2.30	1.70	1.60	1.60	2.10	2.00	3.10
22.....	2.80	4.80	.....	7.40	.70	2.40	5.40	1.40	1.50	2.10	2.80	3.00
23.....	2.80	3.30	.....	4.30	.60	2.20	2.40	1.30	1.50	2.00	3.00	2.80
24.....	2.60	5.40	2.90	2.90	.70	2.20	2.20	1.30	1.50	2.00	2.80	2.60
25.....	4.60	4.00	3.70	2.20	.60	2.20	2.00	1.20	1.40	2.00	2.60	2.40
26.....	5.00	3.60	5.30	1.80	.60	1.00	1.80	1.20	1.40	2.00	2.40	3.20
27.....	4.70	3.50	4.00	1.80	.70	1.00	1.80	1.10	1.60	2.00	2.30	2.00
28.....	5.30	11.90	3.10	1.70	.40	1.00	2.00	1.20	1.50	1.80	2.10	1.90
29.....	5.80	.....	2.80	1.60	.20	1.10	1.40	1.40	1.40	1.70	2.00	1.80
30.....	6.30	.....	2.60	1.60	6.10	1.00	1.30	1.40	1.40	1.70	2.00	2.50
31.....	6.60	.....	2.50	.....	5.60	.....	1.20	2.00	.....	1.70	.....	3.40

[1] Record from United States Weather Bureau.

Ocmulgee River[1] at Macon, Georgia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	2.30	10.40	3.00	1.80	1.20	1.80	7.00	3.40	.90	5.00	1.00
2	3.00	2.00	9.10	3.00	1.70	1.20	1.60	6.00	3.20	.90	5.60	1.00
3	2.80	2.00	8.60	2.50	1.50	1.20	1.40	5.80	3.00	.90	7.00	.90
4	2.60	3.00	8.00	2.50	1.50	1.20	1.30	4.80	2.80	.80	6.50	1.00
5	2.30	2.80	4.90	3.00	1.50	1.20	1.20	9.00	2.60	.80	6.00	1.50
6	2.00	2.60	4.20	2.80	1.50	1.10	2.50	14.20	3.00	.80	5.00	1.50
7	1.80	2.40	3.90	2.80	1.50	1.10	3.00	12.20	4.00	.80	4.00	1.40
8	1.60	2.30	3.80	2.50	1.50	1.00	2.80	9.60	6.00	.90	3.00	1.30
9	3.70	2.20	3.70	2.50	1.50	1.00	2.60	6.90	5.50	11.00	2.80	1.30
10	3.30	2.10	3.50	2.50	1.30	1.00	3.00	5.40	5.00	15.10	2.40	2.00
11	4.50	3.00	3.20	5.60	1.30	.90	4.00	4.00	4.80	8.00	2.30	4.00
12	6.00	7.20	7.10	5.20	1.30	.90	3.80	4.00	4.60	6.00	2.10	9.80
13	6.80	10.00	7.90	5.00	1.20	.90	3.40	3.80	5.00	4.50	2.00	13.20
14	5.50	11.00	6.00	4.60	1.50	1.00	3.20	3.60	5.80	4.30	2.00	10.30
15	3.20	13.70	4.00	4.00	3.00	.90	3.00	3.40	4.60	4.10	1.90	8.40
16	3.80	9.80	3.50	3.80	2.50	.90	2.80	3.10	4.30	3.90	1.80	7.20
17	4.20	7.50	4.00	3.50	2.00	.90	3.00	3.00	4.20	3.60	1.70	3.00
18	3.30	6.20	6.00	3.00	1.70	1.00	3.00	3.00	5.00	3.40	1.70	2.50
19	3.00	5.70	5.00	2.80	2.50	.90	7.60	4.00	5.30	3.20	1.50	2.40
20	2.80	5.20	4.60	6.50	2.30	.90	6.80	3.00	11.30	3.10	1.50	2.20
21	3.00	4.90	4.30	6.00	2.00	.80	7.90	4.50	5.50	3.00	1.50	2.10
22	3.20	5.10	4.00	5.80	1.70	2.00	4.00	4.00	3.00	2.80	1.50	2.00
23	3.00	5.20	3.80	5.50	1.50	2.50	3.00	3.80	2.80	2.60	1.50	2.00
24	3.60	5.60	3.50	4.00	1.30	2.60	3.00	3.60	2.60	2.40	1.40	1.90
25	3.20	6.00	3.20	3.70	1.30	3.00	2.60	5.00	2.70	2.30	1.30	1 80
26	3.30	8.90	6.00	3.50	1.30	2.50	2.30	4.80	2.30	2.10	1.30	1.70
27	3.20	10.40	5.60	3.20	1.30	2.00	3.00	4.60	2.20	2.00	1.20	3.00
28	3.00	9.50	4.00	2.30	1.30	1.80	4.00	4.20	2.10	1.80	1.20	4.00
29	2.80	.....	3.50	2.00	1.30	1.60	3.70	4.00	1.00	1.70	1.10	3.90
30	2.70	.....	3.20	2.00	1.30	2.00	4.00	3.80	1.00	1.60	1.00	3.70
31	2.50	.....	3.00	.....	1.20	.....	7.20	3.60	.....	4.00	.....	3.50

Ocmulgee River[1] at Macon, Georgia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	6.00	3.00	4.60	6.00	3.80	10.90	2.80	4.40	a2.00	0.50	0.50
2	3.40	6.00	4.00	4.50	5.50	3.70	10.00	2.80	4.20	1.80	.77	.50
3	3.20	5.80	10.80	4.30	4.00	3.60	7.80	2.80	4.00	1.60	.85	.65
4	3.00	5.30	10.00	4.20	3.80	3.50	11.80	4.00	5.00	1.40	.67	.62
5	3.00	5.10	6.00	4.00	3.70	3.50	10.00	6.00	4.80	1.40	.55	.54
6	2.80	4.00	4.00	4.00	3.60	3.40	9.50	5.80	4.60	1.20	.45	.51
7	2.70	4.00	5.70	3.90	3.60	3.30	9.00	5.60	4.30	1.00	.36	.44
8	2.60	3.90	10.90	11.20	3.60	3.20	13.40	5.40	4.20	1.00	.47	.40
9	3.00	3.70	8.50	11.00	3.60	3.20	10.00	5.30	4.00	1.00	.55	.46
10	15.00	3.60	6.00	8.00	5.00	3.00	7.00	5.00	3.90	.80	.63	.45
11	14.50	3.50	4.00	7.00	5.00	3.00	5.00	4.90	5.00	.60	.65	2.50
12	11.50	3.50	4.00	6.50	5.50	2.90	4.00	4.70	4.80	.70	.60	2.20
13	7.00	4.00	6.00	6.00	5.30	2.90	3.90	4.50	4.50	.65	.77	1.51
14	6.00	4.20	14.50	5.80	5.00	3.00	3.70	4.60	4.20	.40	.94	1.11
15	5.00	4.70	15.80	5.30	4.80	4.00	3.50	7.00	4.10	.30	.72	1.01
16	3.00	4.50	16.40	5.00	4.60	4.00	3.40	9.70	4.00	.20	.65	1.72
17	2.90	4.20	18.40	4.80	4.20	4.50	3.30	12.20	3.90	.20	.57	.58
18	2.70	4.10	16.80	12.50	5.00	4.30	3.20	13.00	3.70	.17	.55	.64
19	2.60	4.00	12.00	10.00	4.20	4.00	3.30	12.00	3.60	.20	.50	.61
20	2.50	3.90	9.00	8.00	4.00	3.90	3.60	9.00	3.50	.18	.50	.59
21	2.20	3.60	11.00	7.00	3.80	3.80	3.50	6.00	3.50	.25	.50	2.02
22	2.10	3.50	9.00	6.00	4.00	3.70	3.40	10.00	3.50	.22	.50	3.10
23	2.00	3.50	8.00	6.50	4.50	4.00	3.30	9.00	3.40	.21	.50	2.68
24	2.00	3.40	7.00	6.00	5.00	3.90	3.30	6.00	3.40	.21	.50	1.70
25	2.00	3.30	6.00	4.80	5.00	3.80	3.20	4.50	3.30	.17	.49	1.48
26	12.50	3.20	5.80	4.70	7.00	3.70	3.10	4.00	3.20	.19	.49	1.01
27	22.00	3.20	5.50	8.10	12.50	3.50	3.00	4.00	3.20	.18	.47	1.00
28	23.00	3.10	5.40	10.90	7.00	3.40	3.00	5.00	3.20	.18	.43	1.20
29	24.00	.....	5.30	10.00	5.00	3.20	2.90	4.00	3.10	.17	.55	1.30
30	25.00	.....	5.00	7.00	4.00	.....	2.90	4.00	3.00	.22	.54	1.35
31	26.00	.....	4.80	.....	3.90	.....	2.90	4.50	.....	.50	.....	4.46

a From United States Weather Bureau.
12.00 for 1 to 23, estimated by B. M. Hall.
10.00

[1] Record from U.

Ocmulgee River at Macon, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.81	3.00	a2.50	3.10	0.89	0.08	—0.90	1.02	0.11	—0.82	—0.14	9.50
2	3.50	2.90	2.20	3.00	.75	—.11	—1.00	1.50	.12	—.86	—.08	11.08
3	2.20	3.20	2.10	4.60	.63	.56	+.10	1.82	.11	—.88	—.02	12.60
4	1.70	3.00	2.00	3.40	.90	.85	.15	2.22	.28	—.81	10.00	10.20
5	1.42	2.90	2.00	2.90	2.12	1.92	2.00	2.62	.19	—.75	14.20	8.00
6	1.08	13.50	1.90	1.80	2.73	1.52	4.00	3.00	.19	—.79	14.40	6.15
7	.96	10.70	4.00	1.60	1.97	.96	5.30	3.05	.19	—.78	8.80	4.52
8	1.72	7.50	6.00	1.10	1.62	.73	11.00	2.78	.12	—.82	5.40	3.62
9	2.83	13.10	5.00	1.10	.86	.25	20.00	2.41	.08	—.82	3.22	3.00
10	2.77	11.30	4.00	1.40	.61	.01	19.40	1.88	.04	—.82	2.25	2.42
11	2.10	8.70	5.00	1.30	.38	—.06	15.00	1.48	.01	—.73	1.50	1.98
12	1.60	7.00	7.20	1.10	.30	—.10	10.20	.40	—.01	—.62	1.18	1.58
13	1.50	6.30	6.50	1.20	.19	—.17	8.20	.20	—.31	—.75	10.00	1.26
14	1.20	6.50	6.20	1.20	.11	.29	7.10	.13	—.45	—.73	8.10	1.12
15	2.00	5.00	6.00	1.13	.09	.32	7.00	.25	—.80	—.65	5.32	11.70
16	2.50	4.80	6.00	1.12	.07	.20	6.20	1.08	—.68	—.77	1.53	6.00
17	7.20	4.20	5.50	1.09	.05	.25	16.00	.50	—.78	—.80	1.14	4.62
18	5.00	3.40	5.30	1.05	.03	.25	18.20	.60	—.80	—.83	.97	3.94
19	4.50	3.20	5.00	.98	—.05	.30	13.00	.38	—.82	—.85	.85	2.85
20	4.00	3.00	4.90	.94	—.10	.40	7.05	.20	—.91	—.88	.63	2.38
21	3.90	2.90	4.70	.86	—.10	.47	3.80	.11	—.90	—.89	.70	2.00
22	3.70	2.70	4.50	.76	—.15	.56	3.20	.08	—.82	—.90	.62	1.90
23	9.40	2.60	4.20	.71	—.05	.70	3.00	—.06	—.41	—.73	.58	1.76
24	13.80	2.50	5.00	.63	.56	.50	2.90	—.05	—.48	—.40	.58	1.38
25	12.00	2.48	5.00	.63	.50	.30	2.85	.00	—.61	—.52	.51	1.18
26	9.30	2.40	4.80	1.02	.78	—.20	2.70	—.03	—.72	—.25	.51	1.11
27	7.00	2.30	4.70	2.90	.52	—.35	2.40	—.04	—.78	—.08	.50	.96
28	5.80	3.80	4.60	2.32	.84	—.65	2.10	—.07	—.83	—.20	.47	.90
29	5.30	2.80	4.40	1.36	.17	—.75	1.92	—.07	—.91	—.32	.44	.83
30	4.80	.....	4.20	1.02	.12	—.85	1.66	—.09	—.80	—.23	.32	.78
31	3.20	.....	4.10	.....	.12	.....	1.41	—.12	.....	—.18	.....	.70

a Gage heights from March 1 to April 14 supplied from Weather Bureau records.

Chattahoochee River at Oakdale, Georgia, for 1895.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	0.75	0.50	12	.....	1.35	1.10	23	0.20	0.50	2.00
2	.....	1.70	.50	13	.....	1.00	1.00	24	.30	.50	1.20
3	.....	1.00	.55	14	.....	.75	.65	25	.25	.50	1.00
4	.....	.60	.60	15	0.40	.60	.60	26	.20	.55	.55
5	.....	.50	.60	16	.40	.60	.55	27	.25	.55	.80
6	.....	.55	.50	17	.35	.55	.55	28	.25	.70	.75
7	.....	.45	.45	18	.30	.60	.50	29	.30	.75	.70
8	.....	.40	.40	19	.25	.50	.40	30	.50	.45	2.00
9	.....	.60	.40	20	.30	.55	.50	31	.50	.....	2.95
10	.....	.80	.60	21	.20	.50	.65				
11	.....	1.00	1.30	22	.25	.50	1.00				

Chattahoochee River at Oakdale, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	3.20	1.70	1.40	1.40	0.75	0.25	0.35	0.45	—0.40	0.20	0.50	0.65
2.....	2.00	1.55	1.35	1.70	.75	1.40	.40	.50	— .60	.10	.50	1.20
3.....	1.00	1.75	1.40	2.75	.75	1.45	— .45	1.40	— .60	.05	.65	1.70
4.....	1.20	2.10	1.45	1.85	.70	2.10	+ .15	1.70	— .60	— .20	1.13	3.20
5.....	1.10	2.20	1.40	1.35	.65	1.60	.20	.75	— .60	— .30	1.60	2.30
6.....	1.00	2.80	1.35	1.30	3.15	1.15	— .15	.40	— .60	— .35	1.35	1.30
7.....	.80	3.70	1.95	1.10	1.70	.60	+2.00	.20	— .60	— .40	1.20	1.15
8.....	.95	4.30	1.75	1.15	1.20	.40	12.25	.15	— .55	— .50	1.10	1.00
9.....	1.20	5.80	1.55	1.05	.90	.70	17.70	.15	— .55	— .50	1.00	1.00
10.....	1.25	6.55	1.50	1.05	.75	.70	18.45	.10	— .50	— .50	1.05	1.00
11.....	1.00	4.30	1.75	1.05	.65	.65	4.75	.05	— .50	— .60	1.05	.90
12.....	.85	3.30	1.85	1.00	.60	.50	3.25	.05	— .55	— .60	1.60	.70
13.....	.80	2.80	1.55	1.00	.50	.30	3.10	.30	— .60	— .55	3.80	.60
14.....	.75	2.95	1.35	.90	.50	.20	2.90	.25	— .60	— .55	4.60	.65
15.....	.70	4.10	1.20	.90	.40	— .05	1.95	.05	— .60	— .55	2.60	.70
16.....	.85	2.90	1.15	.90	.30	+ .05	3.00	.10	— .65	— .55	1.50	.65
17.....	2.40	2.55	1.10	.85	.30	— .05	4.40	.10	— .65	— .55	1.00	.65
18.....	2.35	2.20	1.35	.85	.25	+ .10	2.70	.10	— .65	— .55	.80	.65
19.....	2.10	2.10	1.70	.85	.25	.15	1.75	— .10	— .65	— .55	.60	.65
20.....	1.50	1.80	1.65	.85	.20	.55	1.90	— .25	— .65	— .55	.50	.65
21.....	1.25	1.60	1.45	.75	.15	1.60	1.65	— .30	— .50	— .55	.40	.60
22.....	1.80	1.45	1.35	.75	.20	.45	1.90	— .30	— .15	— .50	.40	.55
23.....	6.30	1.55	1.40	.65	.20	.50	2.45	— .30	+ .40	— .23	.30	.50
24.....	9.80	1.60	1.45	.70	1.10	.30	2.40	— .30	.60	— .05	.25	.50
25.....	9.95	1.50	1.40	.65	1.55	.20	1.50	+1.00	— .10	+ .05	.20	.45
26.....	5.10	1.40	1.35	.65	.65	— .10	1.30	— .10	— .40	.10	.20	.45
27.....	3.55	1.35	1.25	1.40	.85	+ .45	.90	— .30	— .40	.15	.20	.40
28.....	2.65	1.30	1.20	1.70	.65	— .10	.80	— .20	+ .20	.25	.20	.35
29.....	2.30	1.55	1.15	1.15	.95	— .20	.80	— .30	.45	.90	.20	.35
30.....	2.10	.....	1.20	.85	.40	— .25	.80	— .35	.30	.65	.20	.30
31.....	1.80	.....	1.20	.....	.35	.....	.50	— .40	.....	.50	.....	.25

Chattahoochee River at Westpoint, Georgia, for 1896.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	2.70	1.30	4.10	1.70	4.20	17.....	1.60	0.85	1.10	3.00	3.00
2.....	3.90	1.20	4.00	2.00	4.00	18.....	1.55	.80	1.10	2.60	3.00
3.....	4.50	1.10	3.00	3.25	3.75	19.....	1.50	.80	1.10	2.55	2.90
4.....	6.00	1.05	2.60	8.00	3.60	20.....	1.45	.80	1.10	2.40	2.80
5.....	5.50	1.00	2.40	9.20	3.40	21.....	1.40	.80	1.15	2.25	2.70
6.....	5.00	1.00	2.00	7.60	3.20	22.....	1.40	3.30	1.10	2.25	2.60
7.....	3.65	1.00	1.90	5.50	3.10	23.....	1.30	3.00	1.50	2.20	2.40
8.....	3.20	1.05	1.50	4.30	3.10	24.....	1.20	2.50	1.75	2.20	2.20
9.....	2.75	1.10	1.30	3.45	3.05	25.....	3.00	2.00	1.75	2.90	2.15
10.....	2.60	1.05	1.25	2.80	3.00	26.....	2.00	1.70	1.70	1.90	2.10
11.....	2.20	.95	1.25	2.00	2.90	27.....	1.80	1.60	1.65	1.80	2.10
12.....	2.00	.85	1.20	2.15	2.80	28.....	1.75	1.40	1.60	2.00	2.05
13.....	1.85	.85	1.15	6.30	2.65	29.....	1.60	3.60	1.50	4.00	2.00
14.....	1.70	.90	1.15	5.00	2.50	30.....	1.50	4.20	1.50	4.30	1.95
15.....	1.60	.90	1.15	4.50	3.00	31.....	1.40	.....	1.45	.....	1.90
16.....	1.60	.85	1.15	3.30	3.10						

Etowah River[1] *at Canton, Georgia, for 1892.*

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	1.00	0.80	1.00	0.80	0.80	0.10	0.10	0.20
2	.....	1.00	1.00	.80	.80	.30	.60	.00	.10	.20
3	.....	1.00	1.00	2.00	.70	.30	.40	.00	.10	.20
4	.....	1.00	1.00	3.80	.70	.30	.30	.00	.10	.20
5	.....	1.00	1.00	1.00	2.00	.30	.20	.00	.10	.20
6	.....	9.00	1.00	1.50	2.00	.30	.10	.00	.10	.10
7	.....	17.80	1.00	.80	1.50	.30	.10	.00	.10	.10
8	.....	11.80	1.00	.80	1.00	.20	.10	.00	.20	.10
9	.....	4.00	1.00	.60	.80	.20	.10	.00	1.00	.10
10	.....	3.00	1.00	.60	2.40	.20	.10	.00	3.00	.10
11	.....	2.00	1.50	.60	5.20	.20	.10	.00	1.00	.10
12	1.10	2.00	1.10	.60	5.60	.20	.10	.00	.50	.10
13	1.00	2.20	1.00	.60	3.00	.20	.20	.00	.40	.10
14	.90	2.20	.90	.50	1.80	.20	1.00	.00	.30	.10
15	.90	2.20	.80	.40	1.80	.20	.80	.00	2.00	.10
16	.90	2.20	.80	.40	1.00	.10	.60	.00	1.00	.10
17	.80	2.10	.90	.40	.80	.20	.50	.00	.50	1.00
18	1.40	1.80	1.20	.40	.60	.80	.40	.00	2.00	.60
19	.90	1.70	1.80	.60	.50	.60	.30	.00	1.00	.40
20	.90	5.40	1.00	1.80	.60	.60	.20	.00	.80	2.00
21	.90	2.30	.90	1.40	.50	.60	.20	.00	.60	1.50
22	.80	1.90	.90	1.00	.70	.70	.20	.00	.40	1.00
23	.80	2.20	1.00	1.00	.70	.90	.20	.00	.40	.50
24	1.20	2.00	.90	.80	.60	1.50	.20	.00	.30	.40
25	1.40	2.00	.90	.70	.60	1.50	.10	.00	.20	.40
26	6.00	1.50	.80	1.70	.60	1.00	.10	.00	.20	.40
27	5.00	1.40	.80	1.00	.50	1.00	.10	.10	.20	.40
28	2.40	1.10	.80	2.00	.40	.80	.10	.10	.30	.40
29	1.80	1.00	.80	1.00	.40	.80	.10	.10	.20	.40
30	1.40	1.00	.80	1.00	.30	.60	.10	.10	.20	.40
31	1.40	.....	.80	.....	.30	.60	.....	.10	.....	.40

Etowah River[1] *at Canton, Georgia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	0.60	2.00	0.80	0.30	0.60	0.60	0.10	1.00	0.00	—0.20	0.10
2	1.00	.50	1.00	.70	.30	2.00	1.00	.50	.80	.00	— .20	.10
3	.60	.40	1.00	.70	.90	5.60	.60	.30	.60	.00	— .20	.10
4	.50	.40	1.00	.70	1.20	2.00	.50	.20	.40	.00	— .20	.40
5	.40	.40	1.00	.70	.90	1.00	.50	.80	.20	—.10	— .20	.40
6	.30	.30	1.00	.70	.90	3.00	.40	.60	.00	—.10	— .20	.20
7	.30	.30	1.00	.70	2.00	3.80	.40	.40	.00	—.10	— .20	.20
8	.30	.30	1.00	.60	1.00	2.00	.40	.30	.00	—.10	— .20	.20
9	.30	.30	4.80	.60	2.00	1.00	.40	.30	.10	—.10	— .20	.20
10	.30	.20	2.00	.60	1.00	.60	.40	.30	1.00	—.20	— .20	.20
11	.30	2.00	1.20	.50	.90	.60	.40	.30	3.00	—.20	— .20	.20
12	.30	2.20	1.50	.50	.80	.60	.30	.30	4.00	—.20	— .20	.20
13	.40	4.20	1.30	.50	.70	.60	.30	.30	3.80	—.20	— .20	.10
14	.40	3.00	1.00	.50	.70	.50	.30	.30	1.50	—.20	— .20	.00
15	.40	3.00	1.00	.40	.60	.50	.30	.30	1.00	—.20	— .20	.00
16	.30	12.00	1.00	.40	1.00	.50	.30	.30	.50	—.20	— .20	.20
17	.30	5.00	.80	.40	.90	.50	.30	.30	.30	—.20	— .20	.20
18	.30	3.00	.80	.40	.80	.40	.30	.20	.10	—.20	— .20	.20
19	.50	2.00	.70	.40	.80	.40	.30	.10	.10	—.20	— .20	.20
20	.50	1.50	.70	.40	.70	3.00	.30	.10	.10	—.20	— .20	.20
21	.40	1.40	.60	.40	.60	1.00	.30	.10	.00	—.20	— .20	.10
22	.40	1.30	.50	.40	.50	.80	1.00	.10	.00	—.20	— .20	.10
23	.40	1.00	.40	.30	.50	2.60	.80	.00	.00	—.20	.00	.10
24	.40	1.00	.80	.30	.40	1.00	.60	.00	.00	—.20	.00	.10
25	.40	1.00	1.40	.30	.40	.80	.50	.00	.00	—.20	.00	.10
26	.40	.80	1.00	.30	.40	.80	.40	—.10	.00	—.20	.00	.10
27	.40	.80	1.00	.30	.40	.70	.30	—.10	.00	—.20	.00	.10
28	.60	3.00	.80	.30	.40	.60	.20	—.10	—.10	—.20	.00	.10
29	1.50	.....	.80	.30	.90	.60	.10	—.10	—.10	—.20	+ .20	.10
30	1.40	.....	.80	.30	1.60	.50	.10	—.10	—.10	—.20	.20	.20
31	1.00	.....	.80	.....	1.00	.....	.10	.....	.....	—.20	.....	.20

[1] From United States Weather Bureau records.

Etowah River[1] *at Canton, Georgia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.20	0.50	0.80	0.70	0.60	0.50	0.60	0.60	0.50	0.60	0.50	0.50
2	.20	.50	.80	.70	.60	.50	.60	.50	.50	.60	.50	.50
3	.20	.50	.80	.70	.60	.50	.60	.50	.50	.60	.50	.50
4	.20	.50	.80	.70	.60	.50	.60	1.50	.50	.60	.50	.50
5	.20	.50	.80	.80	.60	.50	.60	.50	.50	.60	.50	.50
6	.20	.50	.80	.80	.60	.50	.60	.50	.50	.60	.50	.50
7	2.00	.50	.80	.80	.60	.50	.60	.50	.50	.60	.50	.50
8	1.00	.50	.80	.80	.60	.40	.60	.50	.50	.60	.50	.50
9	1.00	1.50	.70	.80	.60	.40	.60	.50	.50	.60	.50	.50
10	1.80	1.00	.60	.80	.60	.30	.60	.50	.50	.60	.50	1.00
11	2.00	.80	.50	1.80	.60	.20	.60	.50	.50	.60	.50	2.00
12	1.00	1.00	.50	.80	.60	.20	.60	.50	.50	.60	.40	7.50
13	1.00	1.00	.40	.80	.60	.20	.60	.50	.50	.60	.40	2.00
14	.80	1.00	.40	.80	.60	.20	.50	.50	.50	.60	.40	1.00
15	1.80	1.00	.40	.70	.80	.20	.50	.50	.50	.60	.50	.60
16	1.00	1.00	.40	.60	.80	.20	.50	.50	.50	.60	.50	.60
17	.80	1.00	.40	.50	.80	.20	.50	.40	.50	.60	.50	.60
18	.60	1.00	.40	.50	.80	.90	1.00	.40	5.20	.60	.50	.60
19	.60	1.50	.40	.50	.80	.80	1.00	.40	1.20	.60	.50	.60
20	.60	1.50	.40	.80	.60	.60	1.00	.40	1.00	.60	.50	.60
21	.80	1.00	2.00	.80	.60	.60	.50	.40	.60	.60	.50	.60
22	.80	.80	1.80	.80	.60	.60	3.00	.40	.60	.60	.50	.60
23	.80	.80	.80	.60	.60	.60	1.00	.40	.60	.60	.50	.60
24	.80	.80	.80	.60	.60	.60	.50	.40	.60	.60	.50	.60
25	.80	.80	.80	.60	.60	.60	.50	1.00	.60	.50	.50	.60
26	.60	.80	.80	.60	.60	.60	.50	2.40	.50	.50	.50	.60
27	.50	.80	.80	.60	.60	.60	.50	1.00	.50	.50	.50	1.80
28	.50	.80	.80	.60	.60	.60	.50	.50	.60	.50	.50	1.80
29	.50	.....	.80	.60	.50	.60	.50	.50	.60	.50	.50	.80
30	.50	.....	.80	.60	.50	.60	.50	.50	.60	.50	.50	.80
31	.50	.....	.80	.....	.50	.....	.....	.50	.....	.50	.....	.80

Etowah River[1] *at Canton, Georgia, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	1.00	1.00	1.00	1.40	1.00	2.00	0.60	0.80	0.40	0.10	0.30
2	.80	1.00	1.00	1.00	1.60	1.00	1.00	.60	.80	.40	.10	.30
3	.80	1.00	2.00	1.00	1.00	.80	1.00	.60	.80	.40	.10	.30
4	.80	1.00	2.00	1.00	1.00	.80	1.00	.60	.80	.40	.10	.30
5	.80	1.00	2.00	1.00	1.00	.80	1.00	.50	.80	.40	.10	.30
6	.80	1.00	1.00	1.00	1.00	2.00	.80	.50	.80	.30	.00	.30
7	.80	1.00	1.00	1.50	1.00	1.00	1.00	.50	.80	.30	.00	.30
8	.80	1.00	1.00	4.50	1.00	1.00	2.50	2.00	.80	.30	.00	.30
9	7.60	1.00	1.00	2.00	1.00	1.00	2.00	.80	.80	.30	.00	.40
10	15.50	1.00	1.00	1.60	1.00	1.00	1.00	.80	.80	.30	.00	.50
11	9.80	1.00	1.00	1.40	1.00	.80	1.00	.80	.80	.30	.00	.50
12	3.00	1.00	1.00	1.40	1.00	1.00	.80	.80	.80	.30	.60	.50
13	1.50	1.00	2.00	1.20	.80	1.00	.80	.80	.80	.30	.60	.50
14	1.00	1.00	3.50	1.20	.80	1.00	.80	2.00	.80	.30	.50	.50
15	1.00	1.00	4.00	1.20	.80	.80	.80	1.00	.80	.30	.50	.50
16	1.20	1.00	6.00	1.20	.80	.80	.80	3.60	.80	.30	.50	.50
17	1.80	1.00	3.00	6.00	.80	1.00	.70	10.50	.80	.30	.50	.50
18	1.00	1.00	2.00	3.00	.80	.80	.90	2.50	.80	.30	.50	.50
19	1.00	1.00	1.60	1.50	.80	.80	.60	1.50	.80	.20	.50	.50
20	1.00	1.00	2.40	1.50	.70	.80	.60	1.00	.80	.20	.40	.50
21	2.00	1.00	5.60	1.40	.70	.80	.60	1.00	.70	.20	.40	1.00
22	2.00	1.00	2.80	1.40	.70	.80	.60	1.00	.70	.20	.40	1.00
23	1.00	1.00	2.00	1.40	1.00	.80	.60	1.00	.60	.20	.40	.60
24	1.00	1.00	2.00	1.30	1.00	.80	.60	1.00	.60	.20	.40	.60
25	1.00	1.00	2.00	1.20	2.80	.80	1.00	1.00	.60	.10	.40	.60
26	2.00	1.00	1.80	1.20	2.80	.80	.80	.80	.80	.10	.40	.60
27	1.00	1.00	1.40	1.60	3.00	.70	.80	.80	.60	.10	.40	.60
28	1.00	1.00	1.00	1.00	2.00	.70	.60	.80	.60	.10	.40	.60
29	2.00	.....	1.00	1.40	2.00	.70	.60	.80	.60	.10	.40	.60
30	1.00	.....	1.00	1.40	1.60	2.00	.60	.80	.50	.10	.40	.60
31	1.00	.....	1.00	.....	1.00	.....	.60	.80	.....	.10	.....	.60

[1]From United States Weather Bureau records.

Etowah River at Canton, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Sept.	Oct.	Nov.	Dec.
1	0.60	1.80	0.60	.....	0.00	0.00	1.00
2	.60	1.80	.50	.....	—.20	—.10	1.00
3	.60	1.80	.50	.....	—.30	—.10	.60
4	.60	1.80	.50	.....	—.30	.00	.30
5	.60	1.80	.50	.....	—.40	+2.80	.30
6	.60	2.00	.50	.....	—.40	.80	.20
7	.50	3.00	.80	.....	—.50	.60	.10
8	.70	3.00	.80	.....	—.50	.60	.10
9	.70	3.50	.80	—0.65	—.50	.40	.10
10	.70	2.00	.80	—.60	—.30	.40	.10
11	.70	1.80	.80	—.60	—.30	.40	.10
12	.70	1.80	.80	—.65	—.40	.90	.00
13	.70	1.80	.80	—.70	—.20	3.60	.00
14	.70	1.00	.80	—.75	—.30	1.00	.00
15	.70	1.00	.70	—.60	—.40	.70	.20
16	.70	1.00	.80	—.55	—.40	.70	.40
17	1.00	1.00	.80	—.65	—.40	.40	.20
18	.80	1.00	.70	—.75	—.40	.20	.00
19	.80	1.00	1.00	—.75	—.40	.00	.00
20	.80	1.00	1.00	—.75	—.50	.00	.00
21	.80	1.00	1.00	—.75	—.50	.00	.00
22	1.00	.80	.80	—.60	—.50	.00	.00
23	3.80	.80	.80	—.10	—.50	.00	.00
24	5.80	.80	.80	—.30	.00	.00	.00
25	3.00	.80	.60	—.40	—.10	.00	.00
26	2.00	.60	.60	—.60	—.10	.00	.00
27	2.00	.60	.60	—.60	—.10	.00	.00
28	2.00	.60	.60	—.60	+1.12	.00	—.10
29	1.80	.60	.60	—.60	1.10	.00	—.10
30	1.80	.....	.60	—.70	1.00	1.00	—.10
31	1.80	.....	a1.00	.....	.00	1.40	—.10

a Weather Bureau discontinued observations March 31, 1896; Geological Survey began observations September 9, 1896.

Coosawattee River at Carters, Georgia.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.75	1.25	0.80	2.50	17	0.95	0.50	0.65	0.95	2.35
2	.....	.75	1.10	.85	2.25	18	.90	.50	.60	.90	2.20
3	.....	.75	1.00	1.00	2.00	19	.85	.45	.60	.90	2.05
4	.....	.70	.95	1.05	2.00	20	.80	.50	.55	.90	2.00
5	.....	.70	.95	3.10	1.90	21	.80	.50	.55	.85	1.85
6	.....	.65	.90	1.25	1.80	22	.80	.55	.60	.85	1.85
7	.....	.65	.80	1.00	1.80	23	.75	.65	.80	.85	1.80
8	.....	.60	.70	1.00	1.75	24	.95	.75	1.30	.90	1.70
9	.....	.60	.60	.90	1.65	25	.95	.65	.95	1.00	1.60
10	.....	.65	.50	.90	1.60	26	.95	.60	.60	1.00	1.50
11	.....	.70	.50	6.05	1.50	27	.90	.60	.60	.95	1.50
12	.....	.65	.80	3.50	1.40	28	.90	.55	.70	1.25	1.45
13	.....	.60	.90	2.60	1.40	29	.85	1.60	1.25	1.25	1.40
14	.....	.55	.80	1.40	1.35	30	.85	1.40	.90	3.50	1.40
15	.....	.55	.75	1.00	2.50	31	.80	.....	.80	.....	1.35
16	.....	.55	.70	.90	2.50						

Oostanaula River at Resaca, Georgia, for 1892.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.00	5.80	3.80	4.00	3.50	4.60	2.30	1.90	2.10
2	5.60	5.50	3.90	4.00	3.50	3.60	2.20	1.90	2.10
3	5.30	5.30	4.60	3.70	4.00	3.00	2.20	2.20	2.20
4	5.10	5.10	10.70	3.60	3.70	3.00	2.20	3.60	2.20
5	5.00	5.00	7.50	4.20	3.30	2.90	2.20	4.00	2.20
6	17.20	4.80	6.60	9.80	3.00	3.00	2.20	3.00	2.20
7	28.70	4.70	5.70	8.70	3.10	3.00	1.90	2.40	2.20
8	32.00	4.70	5.00	7.30	3.00	2.80	1.90	3.60	2.20
9	30.70	4.60	5.60	5.40	3.00	2.70	2.30	4.60	2.20
10	28.10	4.60	6.70	9.20	3.40	2.70	2.20	11.40	2.20
11	24.40	5.50	5.60	13.70	3.70	2.60	2.10	10 00	2.20
12	18.30	5.60	5.00	13.50	3.20	2.50	2.10	6.90	2.20
13	10.20	4.80	4.30	12.50	3.50	2.50	2.10	4.30	2.20
14	8.10	4.50	4.10	10.10	3.20	3.10	2.10	3.70	1.90
15	8.70	4.40	3.80	8.50	3.00	2.90	2.10	6.60	2.20
16	7.70	4.20	3.70	7.50	2.90	2.70	2.00	7.80	2.60
17	7.00	4.20	3.60	6.30	2.80	2.50	2.00	6.20	3.00
18	6.90	4.20	3.60	6.00	3.10	2.50	2.00	5.90	5.60
19	6.70	6.50	3.60	5.20	3.30	2.50	2.00	7.20	6.00
20	8.40	6.00	4.30	6.80	3.20	2.60	1.90	5.70	7.00
21	8.00	5.10	5.20	5.70	3.30	2.90	1.90	4.50	10.00
22	6.90	5.10	6.50	5.50	3.10	5.00	1.90	4.10	8.00
23	7.50	5.30	5.40	5.00	7.10	5.20	1.90	3.90	5.60
24	6.90	4.70	4.50	4.60	9.40	3.20	1.90	3.70	4.00
25	6.30	4.40	4.50	4.30	6.00	2.90	1.90	3.50	3.60
26	6.00	4.20	5.30	4.20	4.60	2.70	1.90	3.30	3.40
27	5.70	4.10	4.60	4.30	4.80	2.60	1.90	3.20	3.00
28	5.60	4.00	7.70	3.80	4.40	2.50	1.90	3.30	2.90
29	5.80	4.00	5.60	3.70	4.00	2.40	1.90	3.90	2.60
30	6.60	3.90	4.40	3.70	3.90	2.30	1.90	3.70	2.50
31	.....	3.90	.....	3.60	4.60	.....	1.90	.....	2.30

Oostanaula River at Resaca, Georgia, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	4.60	7.80	4.30	3.70	4.40	3.20	2.40	2.30	1.70	1.40	1.90
2	4.80	4.30	6.30	4.20	3.60	7.20	3.20	2.40	3.60	1.70	1.40	1.80
3	4.70	4.00	5.60	4.00	7.00	7.90	3.80	2.50	2.30	1.70	1.50	1.80
4	4.40	4.10	6.60	4.00	14.50	7.20	3.70	2.40	2.00	1.70	1.60	4.00
5	4.00	4.00	7.20	4.20	13.50	5.00	3.30	4.80	1.90	2.00	1.60	3.80
6	3.70	4.00	6.00	4.80	13.40	7.90	3.00	3.20	1.80	1.80	1.60	3.00
7	3.60	4.00	5.50	5.10	8.70	15.10	3.00	3.50	1.70	1.70	1.50	2.40
8	3.50	4.20	5.20	4.40	7.20	12.20	2.90	3.20	1.80	1.70	1.50	2.00
9	3.40	4.00	10.60	4.10	6.20	7.70	3.30	2.90	1.90	1.70	1.50	1.90
10	3.40	3.80	13.30	4.00	5.90	6.00	3.00	2.50	2.10	1.60	1.50	1.90
11	3.00	9.00	9.00	3.90	5.30	5.20	2.90	2.30	2.90	1.60	1.50	1.90
12	3.00	13.00	8.20	3.90	4.80	4.70	2.80	2.20	4.40	1.60	1.50	1.80
13	3.30	14.10	7.80	3.80	4.50	4.40	2.70	2.30	5.60	1.60	1.50	1.80
14	3.00	15.50	6.70	5.00	4.40	4.30	2.60	2.80	5.20	1.60	1.50	1.80
15	3.00	12.20	6.00	7.80	4.20	4.10	2.50	3.20	4.40	1.60	1.50	1.80
16	3.00	18.90	5.40	6.40	4.70	4.00	2.70	2.80	3.20	1.70	1.50	1.90
17	3.00	20.90	5.20	4.60	5.30	3.90	2.50	2.60	2.50	1.60	1.50	2.20
18	3.00	20.10	5.10	4.30	4.80	3.80	2.50	2.30	2.30	1.60	1.50	2.80
19	3.00	18.30	5.00	4.10	4.40	3.80	2.40	2.20	2.10	1.60	1.50	2.50
20	3.00	16.80	4.80	4.40	4.00	3.90	2.60	2.10	2.10	1.60	1.50	2.20
21	3.00	13.60	4.60	5.50	3.80	4.80	2.60	2.00	2.00	1.60	1.60	2.00
22	3.00	7.90	4.50	5.10	3.70	4.50	3.60	1.90	1.90	1.80	2.00	1.90
23	3.00	7.10	4.50	4.30	3.60	6.70	3.20	1.90	1.90	1.70	2.00	1.80
24	3.50	6.40	4.70	4.00	3.60	5.50	2.60	1.90	1.80	1.60	1.80	1.80
25	4.40	5.90	7.70	3.80	3.50	4.20	2.40	1.80	1.80	1.60	1.70	1.70
26	4.80	5.50	6.30	3.90	3.40	3.90	2.30	1.70	1.80	1.60	1.70	1.60
27	4.80	5.20	5.00	4.00	3.30	3.80	2.30	1.70	1.80	1.60	1.70	1.60
28	4.50	6.90	4.70	4.20	3.70	3.70	2.30	1.80	1.80	1.50	1.70	1.60
29	5.20	.....	4.50	4.30	4.90	3.40	2.30	1.80	1.70	1.50	2.20	1.60
30	5.60	.....	4.80	3.80	7.90	3.20	2.20	1.70	1.70	1.50	2.00	2.60
31	5.10	.....	4.50	.....	6.70	.....	2.30	1.60	.....	1.40	.....	3.90

Oostanaula River at Resaca, Georgia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	3.20	8.10	3.70	2.90	2.40	1.70	2.10	1.90	1.00	2.10	1.30
2	2.90	3.00	7.60	3.80	2.80	2.30	1.90	2.00	1.80	1.00	1.90	1.30
3	2.50	3.20	6.80	4.60	2.80	2.20	1.80	2.10	1.70	1.00	1.70	1.30
4	3.30	7.90	5.80	4.30	2.90	2.10	1.70	1.80	1.50	1.00	1.60	1.30
5	2.20	9.90	5.20	4.40	2.90	2.00	1.60	2.80	1.40	1.00	1.50	1.30
6	2.30	10.10	4.70	4.30	2.80	2.00	1.50	2.10	1.40	1.00	1.30	1.30
7	2.90	6.50	4.80	3.90	2.70	2.00	1.50	1.80	1.30	1.00	1.20	1.30
8	6.00	4.80	5.20	3.60	2.60	2.00	2.00	1.60	1.30	1.00	1.10	1.30
9	4.60	6.30	4.60	3.50	3.10	1.90	1.70	1.50	1.70	1.10	1.10	1.30
10	5.70	9.30	4.00	3.90	3.10	1.90	1.60	1.50	1.90	1.10	1.10	1.80
11	7.00	7.00	3.90	6.90	3.10	1.90	1.50	1.50	1.60	1.10	1.10	4.10
12	6.50	5.20	5.30	6.40	2.90	1.80	1.50	1.50	1.50	1.10	1.10	11.00
13	5.10	9.60	8.10	5.00	4.40	1.80	1.40	1.50	1.40	1.10	1.00	13.80
14	4.10	8.20	7.60	4.40	5.00	1.80	1.30	1.50	1.40	1.10	1.30	9.20
15	3.60	6.50	5.00	4.10	6.10	1.80	1.30	1.40	1.30	1.00	1.30	4.50
16	5.90	6.20	4.80	3.90	4.50	1.80	1.30	1.60	1.30	1.00	1.30	3.40
17	6.80	5.30	5.90	3.70	3.50	1.70	1.90	1.50	1.20	1.00	1.20	3.00
18	5.30	4.90	5.40	3.60	3.20	1.90	2.70	1.50	2.10	1.00	1.20	3.00
19	4.30	6.30	4.60	3.60	3.10	2.10	2.50	1.80	3.70	.90	1.20	2.70
20	3.80	6.70	4.30	4.20	3.90	2.70	2.70	2.40	2.00	.90	1.20	2.40
21	3.60	6.10	7.20	4.60	3.30	2.20	2.90	2.20	1.80	.90	1.20	2.30
22	4.70	5.50	10.00	4.00	3.20	2.10	3.00	2.00	1.60	.80	1.20	2.20
23	4.60	5.00	7.30	3.50	3.20	2.10	3.50	2.10	1.50	.80	1.20	2.10
24	3.90	4.60	5.80	3.40	3.20	2.00	2.50	1.90	1.40	.80	1.30	2.10
25	3.90	4.40	5.20	3.30	3.10	1.90	2.10	1.90	1.20	.80	1.90	2.00
26	4.30	5.60	4.80	3.20	2.80	2.50	2.00	2.80	1.20	.80	1.60	2.10
27	3.80	6.60	4.30	3.00	2.70	2.60	1.90	3.40	1.10	.80	1.40	13.20
28	3.50	7.70	4.00	3.20	2.60	2.50	2.30	2.60	1.10	.80	1.30	12.60
29	3.10	.....	3.90	3.00	2.50	2.00	2.60	4.60	1.00	.80	1.30	8.70
30	3.20	.....	3.90	3.00	2.50	1.80	2.40	3.20	1.00	1.20	1.30	4.20
31	3.20	.....	3.80	.....	2.40	.....	2.20	2.30	.....	1.70	.....	3.90

Oostanaula River at Resaca, Georgia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	7.00	4.70	5.30	5.20	4.10	8.00	2.60	2.90	1.90	3.50	2.10
2	3.30	6.90	4.70	5.20	4.70	4.00	5.20	2.40	2.80	1.90	3.00	2.10
3	3.40	10.20	12.30	5.30	4.60	3.80	4.90	2.30	2.80	1.90	2.70	2.30
4	3.40	8.90	12.00	5.00	4.30	3.70	4.70	2.20	2.80	1.90	2.20	2.30
5	3.40	7.20	9.30	4.70	4.20	3.70	4.00	2.20	2.80	1.90	2.20	2.20
6	3.40	6.30	6.50	4.60	4.30	6.80	3.90	2.20	2.80	1.90	2.20	2.10
7	3.80	6.40	5.80	5.60	5.30	4.80	3.90	2.40	2.70	1.90	2.10	2.10
8	8.80	7.30	5.70	15.30	6.00	3.90	8.00	5.40	2.60	1.90	2.10	2.10
9	20.20	5.20	6.00	13.30	7.70	3.70	8.10	3.80	2.60	2.10	2.10	2.30
10	23.20	5.00	5.20	10.00	7.70	3.50	7.30	3.40	2.60	2.00	2.20	3.00
11	25.80	5.00	4.90	6.70	6.00	3.40	4.90	2.80	2.60	1.90	4.20	2.90
12	26.00	4.90	5.20	5.50	8.70	3.60	4.20	4.30	2.60	2.00	3.90	2.80
13	22.70	4.80	6.00	5.50	9.00	3.80	4.00	3.70	2.60	2.00	3.20	2.50
14	14.90	4.70	13.20	5.20	7.10	3.50	3.80	3.60	2.50	2.00	2.70	2.40
15	6.50	4.70	13.80	5.20	6.00	3.40	3.60	3.20	2.40	1.90	2.40	2.30
16	6.30	4.70	12.40	6.00	5.20	3.40	3.70	3.40	2.30	1.90	2.40	2.30
17	8.10	4.70	11.50	7.80	4.80	6.90	4.00	9.20	2.50	1.90	2.30	2.20
18	7.10	4.40	8.50	6.30	4.70	5.70	3.60	7.50	3.10	1.80	2.20	2.20
19	6.00	4.40	7.20	5.70	4.60	4.20	3.20	5.60	2.70	1.80	2.20	2.20
20	5.50	5.10	12.60	5.20	4.40	3.70	3.00	5.40	2.50	1.80	2.10	2.20
21	13.40	6.20	19.80	4.90	4.20	3.50	3.00	4.50	2.30	1.70	2.20	3.50
22	12.80	6.60	19.90	4.80	4.20	3.80	3.00	6.30	2.20	1.70	2.10	5.20
23	9.90	6.20	17.80	4.70	4.10	3.70	2.90	4.60	2.10	1.70	2.10	4.40
24	7.70	5.50	13.20	4.50	3.90	3.20	2.80	4.00	2.10	1.70	2.10	3.50
25	6.40	5.00	7.70	4.50	5.30	3.10	2.70	3.80	2.10	1.70	2.10	3.10
26	7.50	4.80	7.50	5.30	6.10	3.00	3.20	3.60	2.10	1.70	2.10	3.10
27	7.60	4.70	6.70	5.70	8.60	2.90	3.20	3.30	2.00	1.70	2.10	3.60
28	6.30	4.70	6.30	6.30	7.90	2.80	2.90	4.80	2.00	1.80	2.10	4.60
29	8.00	.....	5.90	5.80	5.50	2.80	2.80	3.70	2.00	2.50	2.10	4.20
30	8.90	.....	5.60	.....	4.80	4.20	2.70	3.30	1.90	2.10	2.10	3.70
31	8.20	.....	.....	.....	4.30	.....	2.70	3.00	.....	2.20	.....	6.20

Coosa River[1] *at Lock No. 4, for 1892.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.3	4.3	3.9	6.8	4.9	2.3	4.3	2.0	2.8	1.2	0.4	3.2
2	4.3	4.1	3.8	5.9	4.8	2.1	3.4	1.9	2.4	1.2	.4	2.8
3	5.8	4.0	3.6	5.5	4.6	2.5	2.5	1.8	2.2	1.2	.3	2.4
4	6.0	3.8	3.5	5.0	4.2	2.8	2.1	1.8	1.8	1.0	.4	2.4
5	5.2	3.8	3.3	4.7	3.8	3.5	2.0	1.7	1.5	.9	.5	2.7
6	4.6	3.7	3.2	6.6	3.6	5.1	2.1	1.7	1.4	.9	.5	2.4
7	4.2	3.7	4.0	20.8	3.5	5.5	2.1	1.6	1.3	.8	1.0	2.4
8	4.6	3.9	5.8	23.7	3.3	4.7	3.3	1.5	1.2	.8	1.0	2.8
9	5.0	4.6	8.0	23.4	3.3	3.8	5.6	1.5	1.2	.7	1.0	2.3
10	5.5	4.8	9.8	22.5	3.3	3.6	6.4	1.4	1.1	.7	1.2	2.2
11	5.8	5.0	10.4	22.3	3.5	3.5	6.3	1.4	1.0	.7	3.2	2.9
12	7.8	4.7	9.5	22.7	3.6	3.0	8.7	1.6	.9	.8	6.9	2.5
13	16.3	4.2	7.2	23.0	4.0	3.4	10.6	1.9	1.0	.8	6.9	2.4
14	19.3	3.8	5.8	22.6	4.0	3.0	10.9	1.7	.9	.8	4.7	2.1
15	19.7	3.8	4.9	21.6	3.6	2.5	11.3	1.6	.9	.7	4.9	2.4
16	19.1	3.9	4.5	20.0	3.3	2.2	9.4	1.5	1.0	.8	3.1	2.8
17	18.8	3.9	4.2	18.4	3.0	2.0	7.5	1.5	3.3	.8	.....	3.1
18	19.6	4.0	4.9	14.4	2.8	1.9	6.0	1.5	1.9	.8	6.0	4.4
19	21.5	4.1	5.9	8.5	3.5	1.8	5.5	1.4	1.3	.7	4.8	5.5
20	23.1	3.9	6.1	6.1	3.3	1.9	8.1	1.9	1.3	.5	4.0	6.9
21	23.4	4.2	5.9	6.0	3.7	2.1	6.4	2.1	1.9	.5	4.2	8.9
22	22.8	5.3	5.4	8.3	4.4	2.4	6.3	2.3	3.2	.5	3.9	9.2
23	22.1	7.2	5.2	8.4	3.8	4.4	5.3	2.4	5.5	.5	3.2	9.5
24	21.3	8.4	7.1	7.1	3.4	3.9	5.3	.....	5.8	.5	2.6	8.1
25	20.0	8.0	7.8	6.1	3.3	3.9	4.6	5.4	4.1	.5	2.2	6.3
26	18.9	6.6	9.4	5.8	3.3	3.3	3.8	7.0	3.3	.4	1.9	5.1
27	16.6	5.0	10.8	5.3	2.9	4.0	3.3	6.8	2.3	.5	1.8	4.2
28	11.0	4.6	11.4	4.8	2.8	4.1	3.0	5.1	1.8	.5	1.7	3.7
29	6.7	4.3	11.8	4.6	2.7	4.2	2.8	4.2	1.5	.5	1.9	3.3
30	5.4	.....	11.1	4.8	2.6	4.5	2.5	3.7	1.3	.4	3.3	2.9
31	4.5	.....	8.9	.....	2.5	.....	2.1	3.2	.....	.4	.....	2.6

Coosa River[1] *at Lock No. 4, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.7	5.6	7.1	3.6	4.5	5.4	1.9	1.0	.2	0.3	—0.1	0.3
2	2.8	5.0	7.9	3.5	5.2	7.4	1.8	.9	.2	.3	— .1	.3
3	3.1	4.4	8.1	3.3	9.7	7.9	1.7	1.1	.5	.3	— .1	.9
4	3.1	3.8	7.9	3.2	14.4	8.0	1.7	1.4	1.2	.3	— .1	1.0
5	3.3	3.5	8.4	3.4	15.1	8.0	1.6	1.4	1.7	.2	.0	1.2
6	3.0	3.3	8.2	3.5	12.5	7.3	1.8	1.8	1.1	.2	.0	1.3
7	2.8	3.1	7.6	3.7	12.5	7.3	1.6	1.6	1.6	.2	.0	1.5
8	2.5	3.1	6.6	3.8	10.5	9.3	1.5	1.5	.5	.3	.0	1.2
9	2.2	3.1	7.7	4.0	9.8	10.4	1.5	1.5	.5	.3	.0	.7
10	2.1	3.0	8.8	3.8	7.9	10.2	1.4	1.4	.4	.3	.0	.6
11	1.9	3.8	10.1	3.3	6.4	7.9	1.5	1.5	.5	.1	— .1	.4
12	2.1	6.5	10.5	3.0	5.6	5.6	1.4	1.4	.8	.1	.0	.3
13	2.0	9.2	9.8	2.9	4.9	4.2	1.4	1.0	1.5	.1	.0	.3
14	2.0	11.3	8.0	3.3	4.4	3.6	1.3	1.4	2.7	.1	.0	.3
15	2.1	12.1	6.9	4.0	3.9	3.1	1.2	1.3	3.3	.0	.0	.3
16	2.6	20.8	5.9	4.4	3.7	3.0	1.3	1.1	3.5	.0	+ .1	.5
17	2.4	20.6	5.3	4.4	3.5	2.9	1.2	1.2	3.0	.0	.0	.6
18	2.1	19.5	4.8	4.3	3.2	2.6	1.1	1.3	2.1	.0	.0	6
19	2.1	18.4	4.5	3.9	3.1	2.5	1.0	1.4	1.5	.0	.0	9
20	2.0	17.8	4.2	3.3	3.0	2.9	.9	1.1	1.0	.0	.0	.7
21	2.0	17.3	4.0	3.6	2.8	2.8	1.0	1.0	.7	.0	.1	.7
22	2.0	16.8	3.8	3.8	2.6	2.4	.9	.8	.6	.0	.1	.6
23	2.0	15.9	3.7	3.7	2.5	3.0	.9	.5	.5	.0	.1	.4
24	2.1	14.0	3.9	3.6	2.3	3.1	.9	.4	.4	.0	.2	.3
25	2.8	9.4	5.9	3.3	2.2	2.9	1.3	.3	.3	.0	.2	.3
26	3.7	6.5	6.0	3.1	2.1	3.8	1.5	.3	.3	.0	.1	.2
27	4.7	5.5	5.8	4.8	2.0	3.7	1.2	.4	.4	.0	.3	.1
28	5.5	6.2	5.4	6.4	2.0	3.4	.8	.2	.2	.0	.3	.1
29	5.8	.....	4.2	5.9	3.0	2.0	.7	.1	.1	.0	.2	.9
30	5.8	.....	4.0	5.4	5.4	1.9	.7	.2	.2	.0	.1	.2
31	5.7	.....	3.7	.....	6.0	.....	1.0	.2	.....	.0	.....	.....

[1] Record from United States Engineer Office.

Coosa River[1] at Lock No. 4, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.3	2.1	7.4	2.8	1.7	0.7	0.7	0.9	1.4	0.1	—0.1	0.0
2	1.5	2.0	7.6	3.4	1.7	.7	.5	1.0	1.4	— .1	— .2	— .1
3	1.3	2.0	7.6	4.3	1.6	.6	.3	1.0	1.0	— .1	— .1	— .2
4	1.3	2.0	6.9	3.9	1.6	.6	.3	1.0	.8	— .3	.0	— .1
5	1.2	2.8	6.0	3.7	1.7	.5	.3	.7	.5	— .4	+ .1	— .2
6	1.2	4.1	5.2	3.9	1.8	.5	.3	.7	.2	— .3	.0	— .2
7	2.5	5.0	4.6	2.7	1.7	.4	1.0	1.2	.1	— .2	— .1	— .3
8	4.1	5.2	4.2	.....	1.4	.4	1.0	1.2	.1	— .2	— .1	— .1
9	4.1	6.0	3.9	.....	1.4	.4	.8	.8	.1	— .2	— .2	.0
10	7.6	6.2	3.7	.....	1.4	.3	.8	.5	.1	— .1	— .3	+ .1
11	9.3	6.3	3.4	.....	1.5	.3	1.3	.3	.0	— .3	— .3	.3
12	9.3	6.8	3.9	.....	2.2	.2	1.1	.2	.3	— .3	— .3	1.5
13	8.1	8.3	5.6	.....	1.9	.2	.5	.2	.4	— .2	— .4	6.0
14	6.8	8.9	5.6	.....	1.9	.2	.3	.2	.7	— .1	— .3	9.6
15	5.4	9.1	5.1	4.1	2.0	.1	.2	.1	.5	— .1	— .2	10.0
16	5.1	8.3	5.1	3.1	2.4	.1	.1	.1	.5	— .1	— .2	8.0
17	4.9	6.7	5.9	2.8	2.8	.1	.1	.1	.4	— .1	— .1	5.0
18	4.8	5.8	5.3	2.8	3.0	.3	.1	.2	.4	— .2	— .1	2.9
19	4.9	5.7	4.8	2.6	2.4	.3	.2	.1	1.4	— .3	.0	2.0
20	4.5	5.9	4.6	3.1	1.7	.7	.6	.6	3.9	— .4	.0	1.6
21	3.9	6.5	7.1	2.8	1.4	.8	1.6	.5	3.1	— .4	.0	1.4
22	4.0	6.6	8.7	3.0	1.4	.9	1.4	.2	2.9	— .3	.0	1.3
23	4.4	6.6	9.2	3.0	1.4	1.0	1.2	.3	1.3	— .4	.0	1.1
24	4.1	6.3	8.3	2.9	1.2	.9	1.4	1.9	.8	— .4	.0	.8
25	3.9	5.2	7.3	2.5	1.2	1.2	1.8	2.6	.5	— .3	.0	.7
26	3.5	5.5	5.8	2.1	1.2	2.4	2.1	2.0	.3	— .3	.0	1.0
27	3.1	5.9	4.7	2.0	1.2	2.4	1.4	1.8	.2	— .3	+ .1	4.9
28	2.8	5.6	4.0	2.0	1.2	1.2	.9	1.5	.2	— .3	.4	6.9
29	2.7	.....	3.6	1.7	.9	1.0	1.9	3.7	.1	— .4	.2	8.4
30	2.5	.....	3.3	1.7	.9	.8	1.3	2.4	.2	— .1	.1	8.5
31	2.2	.....	3.0	.....	.8	.....	.9	1.6	.....	— .1	.....	6.8

Coosa River[1] at Lock No. 4, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	8.4	4.4	5.6	5.2	4.8	2.2	1.6	3.3	0.8	0.9	0.9
2	3.0	8.0	6.1	5.4	5.2	4.0	2.6	1.5	3.1	.8	1.0	.9
3	2.5	9.0	8.2	5.0	4.8	3.8	4.0	1.5	2.7	.8	1.1	.9
4	2.3	9.2	9.4	4.8	4.4	3.6	4.8	1.5	2.6	.8	1.4	.8
5	2.3	9.4	9.8	4.6	4.8	3.4	5.4	1.4	4.1	.8	1.6	.8
6	2.4	8.6	9.0	4.2	4.4	3.4	4.8	1.3	3.1	.8	1.2	.8
7	2.5	8.0	8.0	5.4	4.4	3.4	3.2	1.3	2.8	.8	1.0	.9
8	5.4	7.0	7.5	9.6	5.0	4.0	3.0	1.3	2.8	.9	.9	.9
9	12.4	6.6	6.2	11.6	5.7	4.6	2.8	1.3	2.8	.8	.8	.9
10	15.7	8.8	5.8	12.0	5.8	3.8	2.6	1.4	2.5	.8	.9	.9
11	16.1	7.8	5.4	11.2	6.0	3.4	2.4	1.5	2.1	.7	1.0	.9
12	15.6	5.0	5.4	9.4	5.6	3.0	2.8	1.4	2.0	.9	1.1	.9
13	15.7	5.0	5.4	7.2	5.0	3.0	2.2	1.2	1.8	.9	1.4	1.2
14	15.3	5.2	8.0	5.8	5.0	3.0	3.5	2.9	1.7	.8	1.9	1.2
15	15.1	4.6	11.6	5.2	5.2	3.6	3.3	3.0	1.7	.8	2.0	1.2
16	15.0	4.4	15.6	5.0	5.0	3.4	3.4	2.7	1.6	.8	1.6	1.1
17	15.0	4.2	16.4	5.6	4.4	3.2	3.3	3.1	1.5	.8	1.3	1.0
18	12.4	4.4	13.6	6.2	4.0	3.0	3.1	4.0	1.5	.7	1.1	1.0
19	8.9	4.4	14.6	8.2	4.0	3.0	2.8	7.5	1.7	.7	1.0	.9
20	6.9	4.6	13.4	8.8	3.8	3.6	2.6	8.3	1.7	.7	1.0	.9
21	6.8	5.0	14.2	7.6	3.6	4.0	2.4	6.5	1.7	.6	.9	1.1
22	10.3	5.6	14.4	6.0	3.4	3.2	2.3	7.9	1.6	.6	.9	1.2
23	11.5	5.8	14.6	5.4	3.0	3.4	2.3	7.7	1.4	.6	.8	1.5
24	11.3	5.8	14.0	4.8	3.2	3.0	2.0	7.0	1.3	.6	.8	1.8
25	10.0	5.8	13.6	4.6	3.4	2.8	2.1	5.6	1.2	.6	.8	2.5
26	9.8	5.2	13.0	4.4	5.0	2.6	2.0	4.2	1.1	.6	.8	2.5
27	9.4	5.0	9.8	4.4	6.4	2.4	1.8	3.4	1.1	.6	.9	2.5
28	9.0	4.6	7.4	5.0	9.0	2.8	1.8	3.2	1.0	.7	.8	2.5
29	9.4	.....	6.2	5.6	9.0	2.2	1.9	3.2	1.0	.7	.8	2.5
30	9.2	.....	6.0	5.6	7.8	2.0	1.8	4.0	.9	.7	.8	2.5
31	9.0	.....	5.4	.....	6.0	.....	1.7	3.4	.....	.8	.....	2.8

[1] Record from United States Engineer Office.

Coosa River[1] *at Lock No. 4, for 1896.*

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.0	3.8	3.4	3.5	2.5	0.1	0.6	1.3	0.6	0.2	0.7	1.5
2	4.1	3.8	3.3	5.2	2.4	.1	.5	1.1	.5	2.0	1.2	2.8
3	4.1	3.4	3.0	7.0	2.2	.1	.5	1.2	.3	3.5	1.0	4.7
4	3.5	3.5	2.8	8.5	2.1	.1	.5	1.4	.2	3.0	.6	5.6
5	3.5	3.5	2.8	7.3	2.8	.2	.4	1.4	.2	2.9	.5	3.6
6	2.6	6.5	2.7	7.3	2.9	.2	.5	1.4	.1	1.1	.5	2.7
7	2.1	10.0	3.0	6.8	2.9	.1	1.0	1.2	.1	.6	.5	2.2
8	2.0	11.8	3.1	5.0	2.7	.1	2.7	1.0	.1	.5	2.5	1.9
9	1.8	13.7	3.0	4.1	2.4	.1	4.7	.9	.1	.4	2.5	1.7
10	1.9	13.4	2.9	3.6	2.1	.1	6.2	.7	.0	.3	1.7	1.6
11	2.1	13.0	3.4	3.6	1.8	.2	7.5	.5	.0	.3	1.1	1.5
12	2.4	11.8	4.7	3.6	1.8	.2	7.0	.5	.0	.2	1.3	1.4
13	2.3	10.0	5.2	3.0	1.5	.1	4.8	.5	.0	.2	2.2	1.5
14	2.0	8.7	4.8	2.9	1.4	.1	2.8	.5	.1	.2	2.6	1.5
15	1.8	7.8	4.4	2.7	1.3	.1	2.6	1.0	.0	.2	4.4	1.6
16	1.8	7.6	4.1	2.5	1.2	.1	2.4	.6	.0	.2	6.0	1.4
17	2.8	7.6	5.0	2.5	1.2	.1	2.8	.5	.0	.1	5.4	1.7
18	3.4	6.8	5.8	2.4	1.2	.1	2.8	.5	.0	.1	4.4	2.0
19	4.1	6.0	6.8	2.4	1.1	.1	3.3	.5	.0	.2	3.8	2.0
20	4.0	5.2	7.7	2.2	1.1	.1	3.9	.5	.1	.2	1.8	1.7
21	3.6	4.5	8.0	2.1	1.1	.1	3.4	.4	.1	.2	1.4	1.4
22	4.4	4.1	7.4	2.0	1.0	.1	2.6	.4	.0	.2	1.3	1.8
23	6.9	3.9	6.5	2.0	1.1	.1	2.2	.4	.0	.1	1.1	1.3
24	9.0	3.5	5.7	2.0	1.4	.1	2.0	.4	.0	.1	1.0	1.3
25	9.6	3.3	5.2	2.0	.9	.1	1.9	.5	.0	.1	.9	1.1
26	10.0	3.2	4.8	2.2	1.2	.1	2.0	.4	.1	.1	.9	1.0
27	10.0	3.0	4.3	2.5	1.5	.....	2.0	.5	.1	.2	.9	1.0
28	8.7	3.0	4.0	2.7	1.5	.....	1.9	.7	.0	.2	.9	.9
29	7.8	3.0	4.0	2.4	1.3	.....	1.5	.9	.1	.5	.9	.9
30	5.2	.....	3.6	2.2	1.5	.....	1.3	.8	.2	.5	1.3	.8
31	4.4	.....	3.4	.....	1.4	.....	1.2	.7	.....	.5	.....	.8

[1]Record from United States Engineer Office.

Lock No. 5.—This is a site for a proposed lock to improve the navigation of the Coosa River. It is about 6 miles below the crossing of the Southern Railway at Riverside, Alabama. Blue Eye Creek and Choccolocco Creek flow into the river between Riverside and Lock No. 5.

The record of gage heights furnished by the United States Engineer Corps is presented below:

Coosa River at Lock No. 5, Georgia, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.9	2.5	4.9	3.0	1.3	2.6	1.0	1.5	0.8	0.2	1.9
2	2.8	2.7	2.4	4.0	2.9	1.3	2.7	1.0	1.5	.7	.2	1.6
3	3.3	2.5	2.3	3.6	2.8	1.5	1.5	1.0	1.3	.5	.2	1.4
4	3.7	2.4	2.1	3.3	2.8	1.6	1.2	.9	1.0	.5	.3	1.3
5	3.8	2.3	2.0	3.0	2.5	1.6	1.1	1.0	1.0	.5	.4	1.1
6	3.3	2.2	1.9	3.0	2.2	2.6	1.1	1.0	.8	.5	.3	1.5
7	2.5	2.1	2.1	16.8	2.1	3.1	1.0	.9	.8	.4	.5	1.4
8	2.2	2.5	3.4	19.4	1.9	2.9	.....	.8	.8	.4	.8	1.5
9	2.5	3.1	5.4	18.2	2.1	2.3	3.4	.8	.7	.4	2.0	1.9
10	3.5	3.0	6.7	17.2	2.2	2.2	4.3	.8	.7	.4	1.8	2.0
11	3.8	3.2	7.2	17.1	2.3	2.0	4.0	.9	.6	.4	3.5	1.5
12	4.4	3.0	6.7	17.4	2.4	1.8	5.7	.9	.6	.4	4.5	1.6
13	13.0	2.9	5.0	17.1	2.5	1.5	7.3	1.0	.5	.4	3.8	1.3
14	16.5	2.3	3.7	16.8	2.3	2.0	7.6	.9	.5	.4	2.7	1.2
15	15.8	2.3	3.0	16.1	2.1	1.4	8.0	.9	.5	.4	2.1	1.6
16	14.8	2.4	2.7	15.0	2.0	1.2	7.0	.8	.6	.4	1.9	1.8
17	14.2	2.4	2.6	13.6	1.9	1.1	5.1	.8	1.0	.4	2.0	2.1
18	14.4	2.5	2.4	9.5	1.9	1.1	4.0	.9	.8	.4	1.7	2.4
19	16.7	2.5	3.8	6.3	2.1	1.1	3.5	.8	1.3	.3	1.7	3.4
20	18.4	2.4	4.0	4.1	2.0	1.1	5.0	.8	1.7	.3	2.1	4.4
21	18.4	2.7	3.9	3.7	2.2	1.3	4.5	.9	2.0	.3	2.0	6.1
22	17.3	3.4	3.5	5.7	2.4	2.3	3.5	.9	2.5	.3	1.7	6.6
23	16.5	4.6	3.1	5.7	2.3	2.5	3.4	1.3	3.8	.3	1.7	6.4
24	15.7	5.6	4.9	4.9	2.0	2.3	3.6	1.7	3.8	.3	1.5	5.5
25	14.6	5.4	5.7	4.0	1.9	.....	3.2	3.4	2.4	.3	1.3	4.5
26	13.8	4.5	7.2	3.7	2.0	2.1	3.0	4.3	2.0	.3	1.1	3.1
27	12.2	3.5	8.7	3.3	1.7	2.2	2.8	4.7	1.4	.2	1.2	2.7
28	7.5	3.1	8.7	3.0	1.5	2.4	2.3	3.5	1.2	.2	1.1	2.4
29	4.5	2.7	8.6	2.8	1.5	2.4	1.5	2.7	.9	.2	1.3	1.9
30	3.4	.....	8.0	3.0	1.5	2.7	1.3	2.1	.8	.2	1.8	1.6
31	3.0	.....	6.9	.....	1.5	.....	1.1	2.0	.....	.2	.....	1.5

Coosa River at Lock No. 5, Georgia, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.4	5.0	2.1	2.8	4.7	1.1	0.5	0.2	0.3	0.0	0.2
2	.....	3.0	5.1	2.1	3.5	5.5	1.0	.5	.3	.3	.0	.3
3	.....	2.6	5.6	2.0	6.3	5.9	1.0	.5	.3	.3	.0	.3
4	.....	2.4	5.6	1.9	0.9	5.2	1.0	.6	.5	.3	.0	.3
5	.....	2.1	6.1	2.1	11.5	5.1	1.0	.8	.9	.3	.0	.5
6	.....	2.0	5.9	2.2	10.6	5.0	1.0	1.1	.7	.3	.1	.6
7	.....	1.8	4.6	2.3	19.1	5.0	1.0	1.4	.4	.2	.1	1.0
8	1.5	1.8	4.6	2.3	7.6	6.2	.9	1.7	.3	.2	.1	1.0
9	1.3	1.8	5.7	2.3	6.3	7.2	.8	1.8	.3	.2	.1	.8
10	1.2	1.9	6.4	2.2	5.7	7.2	.8	1.2	.3	.2	.1	.8
11	1.2	2.3	7.3	2.0	4.6	4.9	.7	.8	.5	.1	.1	.5
12	1.2	4.7	7.5	1.8	3.7	3.9	.7	.8	.9	.1	.1	.3
13	1.1	7.1	6.4	1.8	3.2	2.7	.7	.8	1.6	.1	.1	.3
14	1.2	8.0	5.6	2.0	2.7	2.2	.6	1.0	1.9	.1	.1	.3
15	1.2	12.3	4.6	2.2	2.6	2.0	.6	1.0	1.9	.1	.1	.3
16	1.3	18.1	4.0	2.6	2.3	1.7	.6	.8	2.0	.1	.1	.3
17	1.5	17.4	3.4	2.7	2.1	1.6	.6	.8	1.8	.1	.1	.3
18	1.5	15.3	3.1	2.7	2.0	1.6	.6	.9	1.6	.1	.1	.3
19	1.9	14.0	2.9	2.7	2.0	1.5	.5	.....	1.0	.1	.1	.3
20	1.7	13.7	2.6	2.2	2.0	1.4	.5	.7	.7	.1	.1	.4
21	1.6	12.9	2.5	2.3	1.8	1.4	.5	.6	.5	.1	.1	.4
22	1.5	12.4	2.4	2.4	1.7	1.5	.5	.4	.4	.1	.2	.5
23	1.1	10.4	2.3	.....	1.6	1.5	.5	.3	.4	.1	.2	.4
24	1.3	9.7	2.3	.....	1.4	1.9	.5	.3	.4	.0	.2	.4
25	1.3	7.5	3.8	.....	1.3	1.8	.5	.3	.3	.0	.2	.4
26	1.7	4.4	3.9	.....	1.3	1.9	.5	.2	.3	.0	.2	.3
27	2.0	3.6	3.7	.....	1.2	2.7	.5	.3	.3	.0	.2	.3
28	2.9	4.5	3.4	.....	2.8	2.1	.5	.2	.2	.0	.3	.2
29	3.9	.....	2.8	.....	3.4	1.5	.6	.2	.2	.0	.3	.2
30	3.9	.....	2.4	3.6	3.5	1.2	.5	.2	.2	.0	.2	.5
31	3.8	.....	2.3	.....	3.5	.....	.5	.2	.....	.0	.....	1.1

Coosa River at Lock No. 5, Georgia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.4	1.3	5.0	1.8	1.1	0.5	0.5	0.5	0.8	0.0	0.2	0.2
2	1.1	1.2	5.3	2.0	1.0	.5	.4	.5	1.0	.0	.2	.1
3	1.1	1.2	5.2	2.8	1.0	.5	.3	.6	.8	.1	.2	.1
4	1.0	1.3	4.5	2.6	1.0	.5	.3	.7	.5	.2	.1	.1
5	.9	1.7	4.0	2.2	1.0	.4	.2	.6	.3	.2	.1	.1
6	.8	2.3	3.4	2.3	1.0	.4	.2	.5	.2	.2	.1	.1
7	1.5	3.1	3.0	2.4	1.0	.4	.6	.5	.2	.2	.1	.1
8	2.9	3.2	2.7	2.2	1.0	.3	.7	.8	1.3	.2	.1	.1
9	2.8	3.7	2.6	2.0	.8	.3	.7	.6	.2	.2	.1	.1
10	5.7	4.3	2.5	2.5	.8	.3	.8	.5	.3	.2	.1	.3
11	7.4	4.2	2.1	3.3	.8	.3	.9	.4	.3	.2	.0	.5
12	7.5	4.7	3.2	3.1	1.7	.2	.6	.2	.6	.2	.0	2.4
13	6.0	6.1	3.5	3.0	1.3	.2	.4	.2	.8	.2	.0	3.8
14	4.6	6.3	3.8	3.1	1.3	.2	.3	.2	.7	.2	.0	6.7
15	3.6	6.4	3.3	2.7	1.3	.2	.3	.2	.5	.2	.0	7.0
16	3.6	5.7	3.4	2.3	1.5	.2	.3	.1	.3	.2	.0	5.7
17	3.3	4.6	4.5	2.0	1.7	.1	.2	.1	.3	.2	.0	3.6
18	3.3	4.3	3.9	1.7	1.8	.2	.2	.1	.8	.2	.1	1.9
19	3.3	3.6	3.2	1.6	1.5	.3	.2	.1	1.0	.2	.1	1.2
20	2.9	3.7	3.0	2.0	1.5	.4	.4	.1	1.7	.2	.1	1.0
21	2.5	4.3	5.3	1.9	1.0	.5	.8	.1	2.3	.3	.1	.9
22	2.4	4.6	6.3	1.9	1.0	.6	.9	.3	1.8	.3	.1	.8
23	2.6	4.1	6.9	2.0	1.0	.6	.7	.3	1.0	.3	.1	.6
24	2.5	3.4	6.3	1.8	.9	.5	.8	1.7	.6	.3	.1	.5
25	2.4	3.5	5.3	1.6	.8	.8	.9	1.5	.3	.3	.1	.5
26	2.1	4.0	4.0	1.4	.8	1.5	1.1	1.7	.3	.3	.2	.6
27	1.9	4.0	3.2	1.3	.8	1.4	.9	1.2	.2	.3	.2	3.2
28	1.7	4.4	2.7	1.2	.7	1.0	.5	.7	.2	.2	.3	4.5
29	1.6	.....	2.3	1.2	.7	.7	1.2	2.2	.1	.2	.2	5.5
30	1.5	.....	2.1	1.1	.6	.5	1.0	1.6	.1	.2	.2	5.7
31	1.4	.....	1.9	.....	.5	.....	.6	1.2	.....	.2	.....	4.6

Coosa River[1] at Lock No. 5, Georgia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	5.8	2.2	3.0	3.0	2.7	1.9	0.6	1.6	0.3	0.1	0.3
2	1.9	5.6	3.5	2.9	2.8	2.1	2.2	.6	1.5	.3	.1	.3
3	1.5	6.3	5.8	2.7	2.7	1.9	3.4	.6	1.4	.2	.1	.3
4	1.4	6.4	6.8	2.5	3.8	1.6	4.2	.5	1.3	.2	.4	.3
5	1.4	6.5	7.0	2.4	2.8	1.5	4.5	.4	2.1	.2	.7	.3
6	1.4	6.0	6.4	2.3	2.5	1.5	5.7	.4	1.6	.2	.6	.3
7	1.4	5.2	5.5	2.1	2.4	1.6	2.9	.4	1.4	.2	.5	.3
8	3.9	4.8	4.6	6.8	2.9	1.9	2.6	.5	1.3	.2	.3	.2
9	10.5	4.4	4.0	8.5	3.5	2.3	4.1	.5	1.2	.2	.2	.2
10	12.9	4.0	3.5	8.7	3.5	1.9	5.4	.6	.9	.2	.2	.2
11	12.6	3.5	3.3	8.0	3.7	1.3	6.0	1.0	.9	.2	.5	.2
12	12.0	3.0	3.3	6.9	3.7	1.3	5.2	1.1	.8	.2	.6	.2
13	11.4	2.9	3.3	5.0	3.5	1.4	3.4	1.0	.8	.2	.7	.3
14	11.3	2.8	5.1	3.6	2.9	1.4	3.4	1.3	.7	.2	.7	.5
15	11.3	2.5	8.5	3.0	3.0	1.4	1.9	1.5	.6	.2	.9	.5
16	11.3	2.3	13.8	2.8	2.9	1.3	2.0	1.3	.6	.2	.7	.5
17	11.4	2.2	13.6	2.4	2.4	1.3	1.8	1.5	.6	.1	.6	.5
18	9.5	2.2	12.5	4.0	2.0	1.3	1.5	2.0	.6	.1	.5	.5
19	6.5	2.2	11.3	5.5	1.9	1.4	1.4	4.0	.7	.1	.5	.5
20	4.8	2.5	10.3	6.1	1.7	1.5	1.2	5.1	.8	.1	.4	.5
21	4.4	2.9	10.8	5.1	1.7	2.4	1.2	4.0	.7	.1	.3	.5
22	6.9	3.2	10.7	3.8	1.6	1.7	1.0	5.1	.6	.1	.3	.6
23	8.1	3.4	10.9	3.1	1.5	1.7	1.0	5.2	.5	.1	.3	.7
24	7.0	3.5	10.6	2.7	1.4	1.1	1.0	4.6	.5	.1	.3	.8
25	6.8	3.1	10.0	2.5	1.5	1.1	1.0	3.5	.4	.1	.3	.8
26	7.1	2.7	9.0	2.3	2.0	1.2	.9	2.4	.3	.1	.3	1.1
27	6.8	2.5	7.2	2.4	3.6	1.1	.8	1.8	.3	.1	.3	1.2
28	6.5	2.3	5.1	2.6	5.6	1.0	.8	1.6	.3	.1	.3	1.2
29	6.7	.....	4.0	3.3	6.2	.9	.8	1.6	.3	.1	.3	1.3
30	6.5	.....	3.6	3.8	5.3	1.9	.8	2.1	.3	.1	.3	1.4
31	6.3	.....	3.3	.....	3.8	.....	.7	1.9	.....	.1	.3	1.6

Coosa River[1] at Lock No. 5, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.1	1.8	1.7	1.1	0.7	0.1	0.4	0.1	0.3	0.1	0.6
2	2.1	1.9	1.7	2.6	1.1	.7	.1	.4	.1	.6	.5	1.1
3	1.9	1.7	1.5	4.0	1.0	.6	.1	.4	.1	1.0	.3	2.3
4	1.6	1.7	1.5	5.2	1.0	.8	.1	.5	.2	1.3	.2	2.3
5	1.4	1.6	1.5	5.5	1.3	.9	.....	.5	.2	.8	.1	1.8
6	1.1	3.5	1.4	4.5	1.4	.9	.....	.5	.2	.4	.1	1.2
7	1.1	7.1	1.5	3.8	1.3	.8	.....	.4	.2	.2	.1	.9
8	1.0	8.8	1.7	2.8	1.2	.7	.....	.3	.2	.1	.....	.8
9	1.0	10.2	1.6	2.2	1.0	.6	.....	.2	.3	.1	1.0	.7
10	.9	9.9	1.5	1.9	.9	.7	.....	.1	.3	.1	.7	.6
11	1.0	9.4	2.1	1.8	.8	1.0	.....	.1	.3	.1	.4	.5
12	1.1	8.6	2.6	1.7	.7	.8	4.2	.1	.3	.2	.4	.5
13	1.1	7.2	3.0	1.6	.6	.7	2.7	.1	.3	.2	.8	.4
14	.9	5.7	2.7	1.5	.6	.6	1.5	.1	.3	.2	1.0	.4
15	.9	5.0	2.4	1.4	.5	.6	1.0	.1	.3	.2	2.0	.6
16	.9	4.9	1.2	1.3	.4	.5	1.0	.1	.3	.2	3.3	.5
17	1.5	4.7	2.7	1.2	.4	.4	1.4	.1	.3	.2	3.0	.6
18	1.8	4.1	3.3	1.1	.4	.3	1.4	.1	.3	.2	2.3	.7
19	1.8	3.5	3.7	1.1	.4	.3	1.5	.1	.3	.2	1.3	.8
20	2.2	2.9	4.8	1.1	.3	.3	1.9	.1	.3	.2	.8	.6
21	1.9	2.5	5.2	1.0	.3	.3	1.6	.1	.3	.2	.6	.5
22	2.3	2.2	4.8	.9	.3	.3	1.3	.1	.1	.2	.4	.4
23	4.6	2.0	4.0	.9	.3	.5	1.0	.1	.2	.2	.4	.4
24	6.0	1.9	3.4	.9	.4	.6	.9	.0	.3	.2	.4	.3
25	6.7	1.8	3.0	.9	.4	.5	.9	.1	.3	.2	.3	.3
26	7.1	1.7	2.6	.9	.5	.2	.9	.1	.3	.2	.2	.3
27	6.7	1.5	2.4	1.1	.6	.2	.9	.1	.3	.2	.2	.2
28	5.5	1.6	2.2	1.3	.6	.2	.8	.1	.3	.2	.3	.2
29	4.3	1.6	2.0	1.1	.6	.2	.6	.1	.3	.1	.3	.2
30	3.1	.....	1.9	1.0	.5	.2	.5	.1	.3	.1	.4	.2
31	2.4	.....	1.8	.....	.6	.....	.4	.1	.....	.1	.....	.2

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1889.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	15.00	23.50	18.80	8.50	8.80	2.80	2.40	3.70	0.75	2.40	0.90	6.00
2....	19.50	20.50	16.50	9.80	14.50	2.90	3.10	3.60	7.30	1.95	1.05	5.65
3....	18.00	17.50	25.00	10.30	13.20	2.75	4.40	3.00	6.40	1.55	1.85	5.30
4....	16.00	14.80	31.50	11.60	11.00	2.50	5.10	2.95	5.30	1.30	1.90	4.80
5....	25.00	13.00	29.40	10.50	8.50	2.30	6.25	2.90	6.20	1.15	2.85	4.50
6....	33.00	11.50	26.50	9.50	7.00	2.10	6.85	3.70	9.30	1.05	3.65	4.20
7....	33.50	10.40	23.00	8.40	5.80	1.90	6.45	3.45	14.90	.90	3.30	4.00
8....	29.50	9.30	20.10	7.30	4.60	1.70	5.70	2.95	19.00	.70	3.00	3.80
9....	26.80	8.30	17.50	6.80	4.30	2.00	4.75	2.60	14.00	.50	2.75	3.60
10....	28.40	8.00	15.00	6.40	4.00	2.60	3.85	2.00	9.90	.40	2.55	3.40
11....	29.00	7.80	12.80	6.30	3.80	2.85	3.05	1.75	5.50	.30	3.65	3.20
12....	25.50	7.60	11.00	6.00	3.20	4.20	2.85	1.55	5.25	.30	4.30	2.95
13....	22.50	7.30	10.00	5.60	3.00	3.40	2.45	3.85	4.15	.20	4.15	2.75
14....	19.00	7.00	9.20	5.50	3.10	4.00	2.15	3.60	3.30	.15	3.75	2.70
15....	16.00	7.30	8.80	8.00	3.20	3.45	1.95	3.35	2.70	.15	3.50	2.65
16....	13.60	27.50	8.10	16.80	3.00	3.25	4.20	3.15	2.25	.15	4.20	2.50
17....	29.00	49.00	7.20	16.70	2.80	3.05	7.35	3.80	2.00	.10	5.20	2.30
18....	40.50	56.40	7.10	14.00	2.50	2.85	11.35	3.50	1.55	.10	12.45	2.20
19....	38.50	56.60	11.00	12.00	2.35	2.65	11.50	3.20	1.40	.05	18.90	2.10
20....	34.00	53.00	12.50	10.00	2.25	2.45	8.40	2.90	1.30	.05	16.90	2.05
21....	30.30	47.00	12.30	8.90	2.05	2.25	4.60	2.40	1.20	.05	14.10	2.00
22....	28.10	41.50	11.80	8.00	1.85	3.25	4.55	1.90	1.10	.00	11.70	2.00
23....	26.00	36.50	10.80	7.00	1.65	3.45	4.50	1.50	1.00	— .10	9.70	2.00
24....	23.10	32.50	10.00	6.40	1.50	3.20	3.70	1.20	1.00	— .30	7.90	2.00
25....	21.00	28.50	9.80	6.30	1.30	3.00	3.15	.90	.95	— .15	6.60	1.95
26....	20.40	26.50	11.20	6.80	1.25	2.40	3.10	.75	2.25	+ .10	6.30	1.95
27....	28.00	23.50	11.80	6.50	1.15	1.95	4.55	1.00	3.70	.35	6.10	1.95
28....	33.50	21.40	12.30	6.20	1.05	1.55	4.05	.95	3.50	.35	5.90	1.90
29....	33.80	.....	11.00	5.80	.95	1.25	4.00	.90	3.25	.40	5.80	1.90
30....	30.00	.....	10.50	5.50	1.15	1.10	4.00	1.10	2.60	.90	6.30	3.00
31....	27.00	.....	9.80	.....	1.10	.....	3.80	1.05	.....	1.00	.....	4.85

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1890.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	7.70	30.20	58.90	24.50	16.70	7.75	1.80	5.00	8.00	9.30	3.75	1.00
2.....	7.20	26.20	57.40	34.50	13.70	6.50	1.65	4.05	5.80	7.40	3.85	1.00
3.....	6.20	22.50	52.40	34.10	11.95	5.65	1.45	3.25	4.35	6.10	3.10	1.00
4.....	5.20	19.05	45.80	43.60	12.75	5.00	1.25	2.85	3.40	5.10	2.85	1.00
5.....	5.20	16.40	40.85	45.90	14.65	4.40	1.10	3.15	3.10	4.40	2.55	1.00
6.....	4.80	13.90	37.15	44.50	16.50	4.00	.80	3.35	3.85	3.80	2.40	1.00
7.....	4.50	12.10	35.40	38.70	15.00	5.20	.60	3.75	4.35	3.50	2.25	1.20
8.....	4.55	44.30	32.60	34.00	13.50	5.60	.50	4.55	4.80	3.45	2.15	10.05
9.....	5.10	53.95	30.50	29.95	11.95	5.40	.45	4.30	2.85	4.50	2.05	10.10
10.....	5.30	52.90	27.50	26.70	10.10	5.25	.30	4.30	3.20	4.45	2.00	8.95
11.....	5.60	47.50	25.00	23.45	9.30	5.00	.20	6.10	2.90	4.10	1.95	7.10
12.....	5.45	42.20	23.00	20.45	8.35	6.00	.15	6.40	3.45	3.80	1.75	5.80
13.....	5.30	37.20	20.75	17.45	8.35	6.20	.06	5.30	3.95	3.50	1.65	4.60
14.....	5.20	32.65	22.50	14.50	9.00	6.20	1.05	4.50	5.80	3.20	1.60	3.70
15.....	5.60	29.45	38.20	12.15	8.75	5.60	2.55	3.20	5.55	2.80	1.60	3.30
16.....	11.20	26.95	38.00	10.65	8.65	5.05	3.10	2.80	4.50	2.70	1.55	2.95
17.....	19.30	23.95	35.80	10.35	9.50	4.35	3.55	2.50	3.55	2.60	1.65	2.80
18.....	21.00	21.45	32.30	12.95	8.90	4.80	3.65	2.70	2.90	2.40	1.60	2.75
19.....	18.40	18.45	29.00	13.20	8.15	4.20	4.15	2.55	2.45	2.30	1.55	2.20
20.....	15.40	15.65	27.20	13.95	7.95	3.70	4.75	2.40	2.10	2.10	1.50	2.00
21.....	13.30	13.45	32.40	12.15	7.95	3.20	4.20	2.20	1.75	2.00	1.50	2.00
22.....	11.60	12.00	34.45	10.45	9.00	2.80	3.00	1.80	1.70	2.45	1.45	1.90
23.....	10.10	10.40	41.25	9.30	8.40	2.50	2.10	1.40	3.05	4.90	1.35	1.90
24.....	10.70	9.40	40.25	10.65	7.65	2.25	1.75	1.10	3.10	8.45	1.30	1.80
25.....	12.50	9.50	36.75	15.45	6.95	2.25	2.75	1.00	13.05	10.55	1.25	1.80
26.....	13.50	13.50	33.35	26.50	6.85	2.15	12.65	.95	23.90	9.60	1.20	2.30
27.....	12.80	35.20	29.70	28.45	9.60	2.55	13.40	.95	22.65	8.05	1.15	6.80
28.....	11.80	53.10	27.45	26.20	13.20	2.25	10.50	5.10	18.00	6.45	1.10	9.70
29.....	10.60	.....	24.55	23.35	13.55	2.05	9.30	9.55	14.70	5.30	1.05	10.20
30.....	17.60	.....	21.95	19.80	11.95	1.90	7.45	9.15	11.90	4.90	1.00	9.10
31.....	31.70	.....	18.80	.....	9.25	.....	6.50	10.45	.....	4.15	.....	7.30

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1891.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	6.10	33.20	24.00	34.00	5.70	1.80	2.10	6.50	1.00	—0.40	—0.80	3.40
2...	8.60	39.60	23.50	39.40	5.50	1.90	2.00	13.00	1.00	— .30	— .80	3.00
3...	14.30	40.90	20.50	36.80	5.30	1.80	1.90	14.80	1.00	— .20	— .80	2.40
4...	17.90	40.20	19.60	32.50	4.90	1.70	1.80	16.00	.80	— .20	— .80	6.20
5...	15.20	39.30	17.20	28.50	4.50	1.50	1.50	13.00	.70	— .20	— .80	6.80
6...	13.10	36.30	29.00	25.00	4.50	1.40	1.30	9.50	.60	— .20	— .80	21.50
7...	11.10	37.00	53.00	22.20	4.20	1.40	1.40	7.40	.60	— .40	— .80	19.50
8...	10.00	51.50	58.00	19.00	4.00	1.50	2.10	5.80	.60	— .50	— .80	20.00
9...	9.50	51.50	60.40	16.00	3.90	2.10	7.00	5.40	.60	— .60	— .80	20.50
10...	17.50	52.20	58.00	14.20	3.50	2.80	10.40	3.70	.60	— .70	+ .70	17.00
11...	20.90	53.50	54.00	17.20	3.20	3.50	8.20	3.10	.70	— .80	2.10	14.00
12...	26.30	50.50	48.00	27.00	3.20	10.20	6.00	2.70	1.00	— .80	2.80	11.50
13...	30.10	47.60	43.00	26.00	3.10	10.50	4.30	2.50	1.20	— .80	4.40	9.00
14...	25.50	51.40	40.00	22.50	3.00	9.80	3.20	3.00	1.20	— .80	3.80	6.20
15...	21.00	49.50	36.50	19.50	2.80	8.00	2.30	3.40	1.00	— .60	2.50	7.00
16...	18.50	46.50	33.20	17.20	2.60	6.50	2.60	4.00	1.00	— .70	2.00	9.00
17...	17.10	44.30	30.00	15.60	2.50	5.60	2.60	3.00	.60	— .70	1.80	11.00
18...	17.70	41.00	28.00	16.40	2.50	6.30	2.90	2.60	.20	— .70	1.80	11.20
19...	17.10	37.50	26.40	14.50	2.50	7.20	2.50	2.20	.10	— .60	1.50	10.00
20...	15.60	35.00	24.00	13.40	2.50	7.00	2.20	2.00	.10	— .70	1.30	8.50
21...	12.60	33.50	21.00	12.00	2.50	6.00	1.80	1.50	.10	— .70	1.40	7.00
22...	20.20	39.50	19.90	11.00	2.70	5.50	1.60	1.50	.10	— .60	3.00	6.00
23...	31.60	41.00	17.50	10.00	3.00	5.20	1.40	1.40	.10	— .60	8.00	6.00
24...	31.80	39.00	15.00	9.00	3.00	4.80	1.30	1.30	.10	— .50	12.30	6.20
25...	30.10	36.50	12.50	8.20	2.80	4.50	1.40	1.20	.00	— .50	13.30	7.50
26...	30.70	33.00	12.10	7.60	2.60	4.20	2.60	1.10	.00	— .50	10.80	13.20
27...	29.00	29.00	15.00	8.40	2.50	4.10	2.00	1.10	— .20	— .70	7.20	31.00
28...	26.80	26.50	18.20	8.00	2.40	3.70	2.20	1.00	— .20	— .80	5.80	38.90
29...	23.70	.....	19.40	7.30	2.30	2.90	2.00	1.00	— .40	— .80	4.20	31.20
30...	32.70	.....	18.00	6.50	2.10	2.50	2.10	1.10	— .50	— .80	3.80	27.00
31...	33.00	.....	17.00	.....	2.00	.....	2.40	1.00	.....	— .80	.....	22.10

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1892.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	17.90	12.20	10.70	21.80	12.00	3.40	4.60	4.80	9.30	3.90	0.40	5.90
2.....	15.90	10.50	10.30	18.30	11.20	3.20	3.90	3.20	7.60	3.50	.40	5.60
3.....	18.50	9.40	9.70	15.50	9.90	3.50	3.40	7.00	6.50	3.30	1.20	5.30
4.....	18.70	8.50	8.80	15.20	8.80	3.70	3.00	7.40	5.60	3.10	1.60	4.90
5.....	16.40	7.80	8.00	12.00	7.20	3.50	2.90	6.60	4.90	2.80	1.60	6.30
6.....	14.60	7.40	7.80	11.60	6.50	4.70	3.50	5.40	4.90	2.50	1.60	7.50
7.....	13.00	7.80	8.00	56.30	5.90	5.00	5.20	4.80	4.80	2.40	2.00	7.50
8	11.60	7.50	16.50	63.20	5.30	4.90	11.00	3.90	6.40	2.20	3.90	12.20
9.....	10.80	9.00	26.80	62.20	5.20	4.10	26.70	3.60	6.20	2.10	4.60	15.00
10.....	10.50	16.00	28.50	58.00	4.90	4.00	43.50	3.50	5.40	2.00	8.90	13.20
11.....	25.70	13.00	26.70	52.30	4.90	3.80	46.20	3.00	5.10	2.00	10.90	11.00
12.....	34.80	11.30	22.00	45.40	4.80	3.50	41.40	3.00	3.90	2.00	8.30	9.40
13.....	53.00	10.80	18.00	40.70	4.70	3.30	38.30	3.30	3.40	2.00	7.60	8.00
14.....	57.40	9.50	15.80	36.50	4.60	2.80	37.50	3.10	3.30	1.90	5.80	7.40
15.....	55.90	9.00	13.80	32.80	4.50	2.50	34.80	3.90	4.00	1.90	5.00	8.60
16.....	51.70	10.00	13.30	29.50	4.00	2.40	32.80	3.50	5.10	1.90	4.50	10.30
17.....	45.00	11.80	11.20	27.00	3.70	2.00	41.40	3.50	4.90	1.80	4.00	13.10
18.....	40.10	11.00	12.90	24.50	3.60	2.80	38.00	6.00	4.30	1.70	4.20	26.70
19.....	36.60	9.90	24.00	22.40	4.30	1.10	33.00	9.50	6.00	1.00	4.40	28.40
20.....	41.50	10.50	25.50	20.20	4.60	2.90	29.00	11.50	18.30	1.00	4.70	28.40
21.....	41.00	13.50	22.90	18.10	6.50	3.40	28.30	9.50	23.90	.90	5.00	36.50
22.....	36.80	18.00	20.00	15.90	6.30	7.80	29.30	7.40	20.90	.90	4.80	35.80
23.....	34.40	23.90	18.30	13.80	6.00	10.70	25.10	10.20	17.00	.90	4.50	31.50
24.....	31.00	21.20	22.00	12.30	6.00	10.40	21.50	12.30	13.30	1.00	4.20	27.00
25.....	28.50	18.50	29.00	11.30	4.80	8.80	18.80	14.00	10.50	1.00	3.80	23.00
26.....	26.00	16.00	32.00	10.50	3.50	7.90	15.80	14.20	8.00	.90	3.50	19.50
27.....	23.80	14.00	35.80	8.80	4.70	7.20	13.00	13.20	6.10	.80	3.30	16.00
28.....	21.50	12.50	34.00	7.90	4.00	7.10	10.50	11.50	5.00	.70	3.20	13.60
29.....	19.00	11.50	30.50	7.70	3.80	6.20	7.80	12.00	4.90	.70	3.90	11.40
30.....	16.80	.....	26.80	10.50	3.50	5.40	6.20	11.50	4.30	.50	5.90	9.80
31.....	14.00	.....	23.90	.....	3.50	.....	5.50	10.50	.....	.50	.....	8.50

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.20	18.10	23.00	9.40	24.50	12.50	2.50	0.60	0.30	1.10	0.40	1.50
2	8.60	15.90	21.70	9.30	21.20	33.50	2.30	.70	.30	1.00	.40	1.50
3	9.80	14.00	19.70	9.00	30.00	49.60	2.80	1.00	.10	1.20	.40	1.80
4	10.70	12.80	20.50	8.70	51.20	46.00	3.60	1.20	.00	1.40	.40	2.80
5	10.10	12.50	23.00	8.00	52.20	39.00	3.60	1.30	—.10	1.30	.40	3.50
6	9.00	11.80	24.00	8.70	48.00	37.70	3.20	1.20	—.10	1.20	.40	4.20
7	8.40	11.20	22.60	9.30	42.90	39.90	2.70	1.30	.00	1.20	.40	4.10
8	7.90	10.80	20.10	9.00	40.40	39.30	2.40	1.20	+.20	1.20	.40	3.50
9	7.00	10.60	20.00	8.30	37.40	34.00	2.10	1.00	1.40	1.00	.40	3.00
10	6.70	10.20	22.00	7.60	34.30	29.20	1.80	.90	2.00	.90	.60	2.80
11	6.20	12.00	21.80	7.00	30.80	25.10	1.60	.90	2.10	.80	.60	2.30
12	6.50	23.90	20.50	6.40	27.50	21.20	1.60	.80	2.20	.80	.50	1.90
13	7.80	28.30	19.30	6.10	24.40	17.40	2.20	.90	3.20	.80	.50	1.70
14	9.00	27.00	18.10	5.80	21.90	14.70	2.60	3.60	4.30	.70	.60	1.60
15	9.60	25.90	16.30	23.00	19.10	11.60	2.40	4.90	4.30	.70	.60	1.50
16	11.40	52.20	14.70	27.10	16.20	9.60	2.00	5.10	3.90	.60	.60	1.70
17	12.20	55.60	13.20	24.00	14.00	7.60	1.70	4.70	3.30	.50	.60	2.30
18	11.80	54.70	12.20	20.00	11.90	6.70	1.40	3.70	2.50	.50	.60	2.40
19	12.00	51.40	11.30	16.40	11.00	6.50	1.30	2.80	2.10	.50	.60	2.30
20	12.40	46.50	10.70	13.90	8.40	6.90	1.20	2.20	1.80	.50	.60	2.10
21	11.80	41.80	9.90	12.00	6.90	6.90	1.20	1.70	1.40	.50	.70	2.50
22	10.90	37.90	9.30	11.20	6.20	6.60	1.30	1.50	1.30	.50	1.00	2.40
23	11.20	34.50	8.80	10.70	5.60	6.40	1.60	1.30	1.20	.40	1.00	2.30
24	12.90	31.30	12.30	9.90	5.10	5.70	1.70	1.10	1.00	.40	1.10	2.10
25	15.90	28.40	22.20	8.90	4.80	4.90	1.50	1.00	1.30	.40	1.00	1.90
26	19.20	25.90	22.50	7.00	4.50	4.40	1.30	.90	1.20	.40	.90	1.70
27	22.00	23.80	20.00	10.50	4.30	4.00	1.20	.80	1.20	.40	1.00	1.60
28	23.30	23.00	17.00	32.50	5.10	3.50	.90	.80	1.10	.40	1.70	1.50
29	23.10	.....	14.40	33.90	6.10	3.10	.90	.60	1.10	.40	1.70	1.40
30	22.10	.....	12.40	29.00	12.90	2.80	.80	.50	1.10	.40	1.50	3.70
31	20.40	.....	10.90	.....	14.10	.....	.80	.20	.....	.40	.....	7.60

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.30	8.50	27.00	11.40	6.50	1.70	2.50	1.20	5.80	0.55	—0.05	—0.05
2	9.60	7.80	25.60	14.10	5.80	1.60	1.80	1.30	4.60	.45	—.10	—.05
3	7.90	7.30	23.60	23.50	5.80	1.50	1.35	1.40	3.60	.40	—.20	.00
4	6.20	7.90	21.00	24.00	5.80	1.35	1.10	1.95	2.95	.32	—.25	.00
5	5.40	16.90	18.20	22.20	5.50	1.33	.80	2.30	2.45	.25	—.30	.00
6	6.40	22.60	15.90	20.60	5.20	1.20	.60	2.40	2.05	.20	—.30	.00
7	16.80	20.40	14.80	18.90	5.10	1.20	1.00	2.00	1.85	.15	—.30	.00
8	22.60	17.80	14.40	16.30	4.90	1.10	1.30	1.60	1.75	.00	—.30	+.05
9	19.70	17.30	13.80	14.70	4.50	.95	.70	1.30	1.65	—.10	—.30	.05
10	26.90	26.00	12.60	15.70	4.10	.90	.70	1.10	1.60	—.20	—.30	.50
11	34.50	27.80	11.60	25.00	3.70	.80	.60	.80	1.85	—.25	—.30	2.10
12	35.80	25.40	11.50	25.60	3.90	.80	.60	.70	3.40	—.30	—.30	5.70
13	30.90	29.90	16.50	22.70	4.30	.70	.50	.60	5.60	—.30	—.30	10.40
14	25.80	32.10	17.30	19.50	7.00	.60	.50	.50	7.50	—.30	—.15	11.20
15	22.20	29.70	15.80	16.30	6.20	.60	.60	.35	5.70	—.30	.00	8.90
16	23.60	26.00	15.50	15.50	5.70	.60	.70	.60	4.20	—.30	+.05	6.40
17	24.80	22.30	33.10	16.00	5.10	.55	.75	.55	3.25	—.30	.05	4.90
18	22.40	19.10	36.70	17.00	5.00	.50	.70	.45	3.50	—.30	.05	3.90
19	19.30	16.80	33.70	25.30	4.70	.60	.70	.40	3.25	—.30	.00	3.20
20	15.90	16.00	29.50	24.80	4.20	.70	.60	.55	3.35	—.30	—.10	2.90
21	14.10	16.90	27.80	24.00	3.60	.85	.50	1.00	4.10	—.30	—.10	2.60
22	18.60	17.90	29.30	20.40	3.10	.80	.90	1.35	3.60	—.30	—.10	2.20
23	21.30	17.00	29.60	17.30	2.80	.95	1.30	3.80	2.90	—.30	—.10	2.00
24	19.90	16.10	28.00	14.20	2.60	1.10	1.35	5.30	2.20	—.35	.00	1.80
25	17.60	17.30	27.80	12.20	2.40	1.00	1.60	9.20	1.75	—.40	.00	1.70
26	15.50	29.30	25.30	10.50	2.30	1.05	1.50	16.00	1.45	—.40	.00	2.00
27	14.00	31.00	22.10	9.80	2.10	1.40	1.40	20.40	1.20	—.45	—.05	7.70
28	12.40	28.80	19.00	8.70	2.10	1.70	1.30	16.00	1.05	—.45	—.05	9.70
29	11.10	.....	16.10	7.90	2.00	2.35	.20	11.80	.90	—.45	—.05	8.40
30	10.00	.....	14.30	7.00	1.90	2.60	1.10	8.30	.70	—.20	—.05	7.20
31	9.10	.....	12.70	.....	1.90	.....	1.20	6.80	.....	—.05	—.05	6.50

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1.....	6.10	24.10	8.60	16.20	15.20	7.00	4.80	1.80	1.90	0.10	—0.04	0.75
2.....	5.40	21.50	13.20	14.50	13.00	5.90	4.50	1.50	1.80	.00	+ .07	.95
3.....	6.80	21.40	35.30	12.60	11.00	5.10	5.40	1.30	1.80	— .07	.12	1.05
4.....	9.00	21.40	36.70	11.00	9.40	4.60	7.60	1.20	1.70	— .10	.09	1.00
5.....	8.80	19.90	32.40	10.20	8.30	4.20	17.40	1.20	1.90	— .10	. .11	.90
6.....	8.00	17.90	27.80	8.40	7.40	6.70	17.70	1.20	2.60	— .10	.25	1.30
7.....	7.40	16.50	23.80	7.90	7.00	5.70	18.40	1.10	3.05	— .10	.31	1.50
8.....	35.00	16.80	20.60	20.50	8.20	5.10	15.70	1.00	3.70	.00	.30	1.45
9.....	50.60	16.90	20.10	24.00	13.50	4.30	13.10	.90	3.40	— .03	.28	1.90
10.....	49.30	15.80	19.30	21.20	19.70	3.80	11.10	.97	2.90	— .07	.70	1.80
11.....	45.10	14.60	17.50	18.60	23.30	3.10	9.80	1.40	2.40	— .10	1.20	1.45
12.....	40.10	14.10	17.20	15.10	22.00	2.70	7.90	1.50	2.20	— .14	1.10	1.40
13.....	35.00	13.90	18.40	12.60	18.50	2.40	6.50	1.40	2.10	— .14	1.18	1.40
14.....	29.80	12.80	24.90	11.00	15.20	2.20	5.30	1.30	2.00	+ .06	1.35	1.37
15.....	25.70	11.60	37.50	9.50	12.20	2.00	5.40	1.10	1.80	.04	1.35	1.33
16.....	23.40	10.50	47.40	8.60	9.70	2.00	5.60	1.30	1.60	— .08	1.28	1.23
17.....	31.20	9.40	52.00	10.00	8.00	2.70	5.90	1.40	1.40	— .18	1.20	1.12
18.....	32.90	9.00	47.30	15.90	6.90	3.80	5.80	2.00	1.40	— .27	1.05	1.05
19.....	29.20	9.00	42.10	15.80	6.30	4.20	5.10	4.00	1.30	— .31	.88	1.02
20.....	25.80	9.50	38.80	14.00	5.90	4.90	4.60	4.30	1.00	— .37	.82	1.57
21.....	23.10	10.20	48.70	12.00	5.30	4.70	4.00	3.60	1.20	— .42	.70	2.55
22.....	21.60	10.90	51.30	10.40	4.80	4.30	3.60	2.80	1.50	— .45	.60	2.60
23.....	21.60	11.40	47.60	8.90	4.30	4.10	3.40	2.40	1.30	— .50	.50	3.03
24.....	19.80	11.30	42.10	8.00	4.10	3.70	3.30	4.30	1.10	— .35	.75	3.65
25.....	17.40	10.90	37.30	7.20	4.00	3.40	3.60	4.90	.80	— .33	.00	3.31
26.....	16.70	10.30	32.80	7.00	4.30	3.00	3.70	4.00	.60	— .53	.38	4.50
27.....	20.00	9.70	29.10	7.10	5.60	4.40	3.30	3.20	.35	— .70	.64	10.40
28.....	21.20	9.00	26.10	12.50	11.00	5.40	2.90	2.40	.10	— .68	.65	21.02
29.....	22.00	.....	23.60	15.00	13.30	6.00	2.40	2.30	.50	— .67	.65	16.88
30.....	27.40	.....	21.10	16.40	11.20	5.40	2.00	2.10	.30	— .50	.60	13.10
31.....	27.10	.....	18.60	.....	8.90	.....	2.10	2.00	.....	— .32	.....	11.67

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1896.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	11.41	7.92	6.91	10.61	18.24	4.92	1.94	.53	0.38	—0.52	—0.78	7.70
2.....	10.26	8.51	7.66	14.78	33.30	4.28	1.71	.80	.25	— .62	— .77	6.32
3.....	8.90	21.98	7.41	23.00	37.18	3.50	1.44	1.34	.15	— .66	— .42	4.63
4.....	7.60	33.12	6.74	23.50	30.88	5.44	1.48	.89	.05	— .20	— .39	3.40
5.....	6.55	30.02	6.14	19.85	26.40	5.24	1.30	.54	— .00	+ .78	— .33	2.60
6.....	5.74	30.75	6.64	16.70	21.93	4.30	1.15	.42	— .15	.74	— .19	2.05
7.....	5.09	35.92	10.18	14.26	17.88	3.62	1.32	.50	— .23	.68	— .19	1.70
8.....	5.24	35.08	12.04	12.55	13.95	3.27	2.20	.60	— .30	.40	— .17	1.47
9.....	5.76	36.21	14.89	11.20	10.80	6.60	8.40	.68	— .37	.09	— .18	1.21
10.....	6.46	36.52	13.69	10.02	8.60	8.18	6.98	.64	— .44	— .15	— .21	1.10
11.....	6.58	33.65	12.45	9.04	7.11	18.39	5.37	.55	— .44	— .28	— .30	.89
12.....	6.25	29.45	13.97	8.33	6.09	15.13	3.95	.45	— .46	— .28	— .20	.84
13.....	5.79	25.97	16.15	7.62	5.34	10.77	2.99	.38	— .50	— .48	— .22	.80
14.....	5.26	27.41	15.35	7.86	4.77	7.66	2.45	.35	— .60	— .49	— .11	.75
15.....	4.82	33.25	13.56	11.65	6.13	5.60	2.16	.31	— .59	— .46	— .10	1.20
16.....	4.87	31.02	13.86	13.90	5.45	4.33	2.13	.26	— .59	— .43	— .01	1.25
17.....	6.03	27.30	22.30	12.36	4.65	4.74	2.15	.13	— .60	— .60	+ .26	1.25
18.....	8.61	23.65	27.75	10.57	3.94	4.20	2.42	.40	— .60	— .63	.46	1.60
19.....	9.14	20.09	29.70	9.03	3.44	6.18	2.46	.50	— .60	— .78	.52	1.90
20.....	8.53	17.00	37.68	7.81	3.05	6.00	2.24	.40	— .61	— .82	.45	1.70
21.....	7.87	14.45	37.92	6.88	2.91	5.32	2.16	.34	— .64	— .82	.39	1.50
22.....	8.85	12.20	33.55	6.15	2.77	4.91	1.90	.29	— .64	— .84	.38	1.33
23.....	22.48	10.32	29.12	5.56	2.87	4.46	1.71	.22	— .36	— .84	.38	1.20
24.....	29.26	9.13	25.85	5.67	2.90	4.19	2.06	1.06	— .45	— .78	.37	.98
25.....	26.52	8.60	23.54	5.76	2.87	4.04	2.53	.95	— .61	— .80	.37	.92
26.....	22.44	8.35	21.28	5.30	2.97	3.37	2.17	.79	— .64	— .82	.37	.77
27.....	18.55	7.90	18.72	5.26	3.66	2.85	1.70	.77	— .71	— .82	.08	.71
28.....	14.92	7.40	16.35	10.47	3.59	2.69	1.28	1.35	— .76	— .78	.09	.59
29.....	12.14	7.00	14.30	16.06	6.52	2.54	.94	1.30	— .67	— .80	.33	.52
30.....	10.18	.....	12.69	14.18	6.50	2.21	.76	.95	— .55	— .80	1.00	.48
31.....	8.88	.....	11.40	.....	5.78	.....	.64	.60	.....	— .78	.....	.48

[1] Record from United States Engineer Office.

Greenbrier River at Alderson, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	2.25	2.50	7.00	3.05	2.07	2.47	4.50	1.63	6.60	1.67	4.75
2	3.08	2.27	2.82	6.60	3.35	1.97	2.25	3.75	1.60	4.02	1.73	3.85
3	2.65	4.95	2.70	5.50	3.05	1.90	2.20	4.35	1.55	3.20	1.70	3.40
4	2.25	6.30	2.50	4.40	4.15	1.88	2.10	3.55	1.60	2.80	1.80	3.05
5	2.45	4.55	2.35	3.85	4.60	1.85	2.35	3.05	1.55	2.55	7.67	2.80
6	2.40	3.55	2.33	3.20	3.70	2.00	2.10	2.72	1.60	2.38	9.50	2.65
7	1.90	4.80	2.30	3.10	3.23	2.05	2.55	2.50	1.60	2.20	4.85	2.60
8	1.93	4.20	2.40	2.95	2.95	2.20	a3.08	2.35	1.60	2.10	3.60	2.50
9	1.95	3.60	2.60	3.00	2.85	2.20	6.95	2.25	1.63	2.00	3.15	2.45
10	2.10	3.40	2.70	3.05	2.65	2.20	6.40	2.10	1.64	1.95	2.85	2.65
11	2.05	3.15	2.60	3.10	2.45	2.70	4.28	2.10	1.60	1.90	2.60	3.10
12	2.05	2.85	2.90	3.15	2.85	2.48	3.47	2.10	1.57	1.85	2.48	2.93
13	2.05	2.20	3.00	3.05	2.25	2.20	3.08	2.00	1.55	2.20	2.40	2.78
14	2.30	5.80	2.75	3.00	2.25	2.10	2.85	1.90	1.53	2.15	2.30	2.62
15	2.20	5.50	2.85	2.98	2.65	2.00	2.58	1.95	1.55	2.13	2.25	2.60
16	1.70	4.15	2.95	2.95	2.55	2.05	2.48	2.10	1.95	2.10	2.15	3.00
17	1.70	3.60	6.75	2.75	2.30	2.08	2.42	2.00	1.75	2.00	2.10	3.00
18	1.72	3.05	5.60	2.60	2.10	2.10	2.40	1.85	1.63	1.95	2.05	2.85
19	1.73	2.85	4.50	2.55	2.05	2.05	2.35	1.85	1.57	1.90	2.03	2.65
20	1.73	2.60	6.40	2.50	2.05	2.08	2.28	1.80	1.75	1.85	2.00	2.55
21	1.82	2.38	5.20	2.40	2.30	2.05	2.15	1.75	1.70	1.78	2.00	2.43
22	1.85	2.42	4.50	2.35	2.40	1.97	2.10	1.65	1.70	1.75	2.09	2.35
23	1.90	2.38	4.35	2.35	2.50	1.95	2.07	1.73	1.64	1.73	2.20	2.25
24	2.65	2.25	4.15	2.40	2.50	1.90	2.58	1.93	1.69	1.70	2.22	2.20
25	4.20	2.45	4.15	3.10	2.60	1.95	2.64	1.95	1.60	1.70	2.20	1.90
26	3.93	2.33	3.85	3.05	2.65	3.20	5.38	1.96	1.53	1.73	2.18	1.70
27	3.23	2.28	3.80	3.00	2.55	3.75	3.85	1.93	1.53	1.70	2.15	1.50
28	2.85	2.22	3.70	2.80	2.45	3.20	3.10	1.87	1.55	1.80	2.15	1.40
29	2.60	2.28	3.15	2.68	2.42	3.10	2.80	1.70	1.62	1.73	2.45	1.80
30	2.38	.....	a10.50	2.65	2.28	2.80	2.55	1.70	4.93	1.70	5.55	1.95
31	2.30	.....	8.88	.....	2.17	.....	3.83	1.67	.....	1.70	.....	2.05

a Heavy rain.

New River at Fayette, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.70	3.75	22.25	0.20	2.85	6.08	4.60	1.10	14.90	1.25	12.80
2	3.60	4.90	3.30	23.60	6.60	2.60	5.00	5.10	1.00	9.45	1.00	11.50
3	4.80	12.50	2.95	21.15	6.70	2.75	4.10	4.85	.90	6.00	1.30	8.08
4	3.70	11.80	2.50	17.60	7.05	2.95	2.80	4.50	.80	4.50	2.15	7.40
5	3.10	9.65	2.20	15.40	7.30	3.55	3.00	4.25	.80	3.45	6.98	5.80
6	2.19	7.80	2.00	11.10	7.00	3.58	3.15	4.00	1.00	3.10	17.10	5.32
7	1.75	7.65	3.40	10.30	6.15	3.35	3.45	3.65	1.20	2.65	13.25	4.95
8	1.40	11.55	3.70	9.00	5.20	3.55	3.90	3.90	2.50	2.05	6.53	4.40
9	1.20	11.40	4.50	8.20	4.70	3.75	17.30	3.80	2.30	1.40	7.65	.....
10	1.90	8.65	4.00	7.10	4.55	4.00	25.20	3.60	2.00	1.90	6.30	.....
11	3.00	5.35	3.35	6.20	4.30	3.35	14.50	3.20	1.50	1.65	4.85	.....
12	2.75	4.15	3.70	6.05	4.05	3.00	14.00	2.95	1.25	1.70	3.00	.....
13	2.90	4.30	4.15	5.80	3.65	3.60	13.05	2.70	1.20	2.10	3.20	.....
14	2.40	7.90	5.00	5.50	3.30	3.00	12.00	2.10	1.15	2.80	3.50	.....
15	2.60	10.70	6.00	5.20	3.30	2.70	8.60	2.45	.90	3.30	3.60	.....
16	2.30	9.00	11.00	5.05	3.40	2.50	7.15	2.40	1.40	3.00	3.55	.....
17	2.10	7.50	14.93	4.85	3.20	2.40	6.05	2.30	1.30	2.80	3.25	.....
18	1.95	5.00	15.75	4.70	3.05	2.60	5.00	2.05	1.23	1.95	2.90	.....
19	2.00	4.70	15.05	4.45	3.15	3.00	4.10	1.85	1.00	1.10	2.45	6.30
20	2.30	4.20	13.00	4.20	3.25	3.20	4.40	1.40	.90	.85	2.45	5.60
21	2.50	2.90	11.50	4.30	3.50	3.40	5.40	1.25	.90	.50	2.60	5.00
22	2.10	2.35	11.00	4.50	3.75	3.75	5.70	1.35	.90	.40	2.90	4.65
23	2.40	3.30	10.15	4.70	3.60	4.00	4.95	1.85	.80	.50	3.00	4.05
24	2.60	4.05	9.40	4.90	5.90	4.45	4.10	1.50	1.05	1.45	2.95	3.70
25	6.00	4.60	8.85	5.10	5.45	5.15	4.45	2.10	1.10	1.30	2.70	3.00
26	10.00	4.80	8.15	5.00	5.00	6.30	4.47	2.35	1.10	1.20	2.72	.....
27	8.10	4.30	7.50	5.30	4.10	8.90	4.20	2.70	1.10	1.00	2.70	2.00
28	7.55	4.00	6.60	5.45	4.00	7.90	4.30	2.40	1.10	.70	3.10	2.75
29	6.70	3.90	7.40	5.80	3.55	7.53	4.50	2.15	.70	1.40	7.45	2.90
30	4.90	.....	18.40	6.00	3.20	6.80	4.45	1.75	.80	.60	8.30	2.50
31	4.00	.....	23.40	.....	8.23	.....	4.85	1.30	.....	1.30	.....	2.70

No observations December 9 to 17; wire gage broken.

French Broad River at Asheville, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	3.40	.....	3.80	2.80	2.90	2.56	3.20	2.50	2.65	2.75	5.80
2	3.40	3.40	.....	4.20	3.20	2.90	2.55	3.10	2.63	2.63	2.65	4.50
3	3.30	4.00	.....	3.70	4.60	2.90	2.65	3.25	2.70	2.60	2.65	4.10
4	3.20	3.70	.....	3.45	4.10	3.13	2.85	3.10	2.73	2.50	2.85	3.80
5	3.20	3.60	.....	3.30	3.90	2.90	2.86	2.90	2.95	2.45	6.10	3.80
6	3.30	4.05	.....	3.27	3.70	2.90	4.10	2.85	3.20	2.43	5.50	3.60
7	3.15	4.60	.....	3.25	3.50	2.73	5.10	2.85	3.10	2.40	5.43	3.50
8	3.10	4.43	.....	3.20	3.26	2.70	9.85	2.90	2.90	2.40	3.45	3.40
9	3.00	5.45	.....	3.15	3.20	3.15	8.73	2.85	2.65	2.40	3.35	3.40
10	2.75	4.70	.....	3.15	3.07	2.90	7.00	3.00	2.53	2.40	3.25	3.30
11	2.90	4.20	.....	3.02	3.05	2.75	6.10	3.00	2.55	2.40	2.75	3.25
12	2.90	3.95	.....	3.50	3.05	2.70	5.00	2.95	2.85	2.45	3.50	3.25
13	2.85	4.85	.....	3.25	3.03	2.67	4.80	2.80	2.55	2.50	4.25	3.20
14	2.85	4.45	.....	3.25	3.05	2.65	4.50	2.85	2.55	2.65	4.23	3.20
15	2.75	3.95	.....	3.15	2.87	2.60	4.30	2.95	2.57	2.65	4.20	3.25
16	2.80	3.80	3.50	3.10	2.80	2.60	4.25	3.25	2.57	2.45	3.85	3.30
17	2.80	3.70	3.40	2.95	2.76	3.15	4.15	2.95	2.65	2.43	3.75	3.30
18	3.40	3.60	3.40	2.90	2.76	3.30	4.03	2.80	2.53	2.40	3.63	3.25
19	3.20	3.50	3.16	2.93	2.70	3.39	3.80	2.78	2.50	2.43	3.50	3.10
20	3.15	3.40	3.70	2.93	2.70	3.18	3.75	2.80	2.40	2.46	2.95	3.10
21	3.15	3.40	3.30	2.93	2.70	2.95	3.70	2.80	2.40	2.45	2.93	3.05
22	3.10	3.30	3.20	2.95	2.90	3.00	3.65	2.65	2.37	2.42	2.90	3.05
23	5.30	3.35	3.20	2.95	3.05	3.14	3.63	2.75	2.50	2.45	2.70	3.14
24	6.50	3.35	3.30	2.95	3.10	3.15	3.60	2.70	2.50	2.45	2.85	3.00
25	5.80	3.30	3.20	2.92	3.00	3.15	3.55	2.70	2.45	2.45	2.80	2.95
26	4.40	3.35	3.15	2.86	2.70	2.93	3.35	2.70	2.45	2.45	2.90	2.90
27	3.95	3.25	3.10	2.82	3.05	2.80	3.40	2.60	2.35	2.45	3.10	2.90
28	3.75	3.35	3.10	2.82	2.75	3.05	3.50	2.60	3.00	2.47	4.05	2.87
29	3.60	3.30	3.50	2.82	2.75	2.75	3.40	2.50	2.70	2.50	4.95	2.85
30	3.40	.....	3.25	2.80	2.73	2.63	3.35	2.50	2.67	2.50	6.20	2.83
31	3.40	.....	3.30	.....	2.70	.....	3.25	2.50	.....	2.45	.....	2.83

Tuckaseegee River, three miles above Bryson, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.19	2.70	1.86	2.10	2.00	4.30	17	3.70	2.40	2.10	1.70	2.40	2.50
2	2.31	2.60	1.86	1.90	1.85	3.60	18	3.70	2.20	2.05	1.70	2.30	2.65
3	2.25	2.56	2.00	1.85	1.80	3.30	19	3.20	2.10	2.10	1.70	2.25	2.50
4	2.30	2.50	1.90	1.80	2.60	3.10	20	3.30	2.10	2.10	1.70	2.20	2.20
5	2.53	2.15	2.10	1.77	4.45	3.00	21	5.00	2.15	1.85	1.70	2.20	2.40
6	4.90	2.50	2.50	1.75	2.80	2.90	22	6.00	2.10	2.80	1.70	2.15	2.30
7	4.20	2.70	2.10	1.72	2.40	2.80	23	3.97	2.10	2.20	1.70	2.10	2.40
8	8.05	2.56	2.05	1.70	2.30	2.70	24	3.80	2.20	2.00	2.00	2.05	2.20
9	6.90	2.50	2.00	1.70	2.20	3.00	25	3.70	2.20	1.85	1.80	2.00	2.10
10	4.50	2.50	1.95	1.70	2.10	2.70	26	3.40	2.70	1.80	1.76	2.00	2.05
11	4.00	2.50	2.10	1.70	2.00	2.65	27	3.30	2.10	1.80	1.70	3.30	2.30
12	4.30	2.40	2.00	2.00	5.00	2.60	28	3.20	2.05	1.80	1.70	3.10	2.20
13	3.90	2.25	1.98	1.90	3.30	2.55	29	3.03	2.00	1.80	1.80	5.10	2.30
14	3.60	2.30	1.90	1.90	2.60	2.50	30	2.90	1.90	2.30	2.00	6.50	2.35
15	3.40	2.25	2.10	1.85	2.40	2.80	31	2.80	1.88	.....	2.70	.....	2.30
16	4.10	2.60	2.10	1.70	2.60	2.70							

Little Tennessee River at Judson, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	3.35	2.60	2.90	3.10	7.70	17	4.00	3.60	2.70	.....	3.70	4.53
2	2.80	3.30	2.60	2.80	2.90	6.30	18	3.65	3.10	2.70	.....	3.68	3.83
3	2.77	3.30	2.70	2.78	2.80	5.30	19	3.64	3.00	2.60	.....	3.60	3.88
4	2.95	3.30	2.80	2.68	2.99	4.30	20	3.70	3.00	2.70	.....	3.50	3.80
5	2.85	3.21	2.90	2.60	5.70	4.40	21	3.70	3.20	2.70	.....	3.50	3.80
6	3.82	3.19	2.90	2.53	4.55	4.30	22	4.10	3.85	2.67	.....	3.50	3.79
7	4.22	3.15	2.80	2.55	3.30	4.20	23	5.11	2.83	2.18	.....	3.50	3.78
8	6.70	3.13	2.60	2.54	3.30	4.10	24	4.28	2.92	2.08	.....	3.50	3.78
9	8.80	3.19	2.55	2.53	3.51	4.10	25	4.20	3.00	2.60	3.10	3.40	3.75
10	5.70	3.21	2.53	2.53	3.50	4.90	26	4.10	3.00	2.54	2.90	3.50	3.45
11	8.95	3.12	2.50	.....	3.40	4.80	27	3.85	2.80	2.60	2.90	3.60	3.46
12	4.65	3.10	2.64	.....	4.30	3.88	28	3.92	2.80	2.60	2.80	3.70	3.54
13	4.50	3.20	2.63	.....	5.70	3.89	29	3.80	2.90	2.60	2.90	6.10	3.46
14	4.20	3.10	2.53	.....	4.30	3.89	30	3.56	2.80	3.30	3.10	7.70	3.61
15	3.95	3.90	2.84	.....	4.20	4.30	31	3.45	(a)	.....	3.00	.....	3.60
16	4.00	3.70	2.75	.....	3.30	4.60							

a Rope broken.

Hiwassee River at Murphy, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	3.72	4.02	3.65	3.74	3.66	5.20	17.....	4.48	3.78	3.60	3.65	4.50	4.05
2.....	3.70	4.02	3.61	3.68	3.70	4.70	18.....	4.54	3.74	3.60	3.56	3.95	4.00
3.....	3.75	4.11	3.62	3.65	3.72	4.52	19.....	4.35	3.70	3.58	3.50	3.91	4.00
4.....	4.00	3.95	3.61	3.60	4.90	4.52	20.....	4.28	3.68	3.56	3.60	3.90	4.00
5.....	3.90	3.90	3.61	3.62	4.10	4.20	21.....	4.32	3.70	3.56	3.60	3.90	4.00
6.....	4.62	3.90	3.90	3.55	3.90	4.20	22.....	4.60	3.70	3.62	3.56	3.85	4.00
7.....	4.98	3.95	3.66	3.60	3.90	4.15	23.....	5.10	3.65	3.85	3.60	3.80	3.95
8.....	6.72	3.90	3.62	3.51	3.90	4.10	24.....	4.61	3.90	3.60	3.90	3.80	3.95
9.....	6.95	3.86	3.60	3.60	3.82	4.30	25.....	4.40	3.80	3.60	3.70	3.80	3.95
10.....	5.24	4.00	3.60	3.65	3.80	4.10	26.....	4.30	3.72	3.60	3.62	3.84	3.90
11.....	4.75	3.90	3.60	3.65	3.76	4.10	27.....	4.30	3.72	3.60	3.62	4.00	3.90
12.....	4.82	3.81	3.67	3.65	7.53	4.10	28	4.25	3.70	3.65	3.65	4.00	3.90
13.....	4.77	3.81	3.56	3.72	5.40	4.05	29.....	4.12	3.70	3.60	3.74	5.03	3.90
14.....	4.65	3.72	3.58	3.65	4.53	4.02	30.....	4.01	3.65	4.20	3.80	6.10	3.90
15.....	4.42	3.75	3.80	3.65	4.30	4.10	31.....	4.02	3.65	.....	3.82	.....	3.90
16.....	4.55	3.92	3.62	3.60	4.12	4.05							

Tennessee River at Chattanooga, Tennessee, for 1890.

[Furnished by L. M. Pindell, observer in charge, United States Weather Bureau.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	4.9	8.0	40.2	10.0	7.5	6.1	3.2	5.8	7.6	9.4	6.8	2.4
2.....	5.2	7.3	42.5	9.8	7.1	6.6	2.9	5.2	5.6	8.1	6.6	2.4
3.....	5.1	7.3	41.0	9.4	6.7	5.3	2.9	4.7	5.7	7.7	5.7	2.3
4.....	5.0	7.4	34.4	9.7	6.8	5.3	3.0	4.7	4.0	7.2	5.3	2.3
5.....	5.0	7.2	23.0	12.2	7.0	5.2	3.0	4.8	3.6	6.4	5.0	2.3
6.....	4.8	7.8	15.1	14.0	7.5	5.3	3.0	4.5	3.2	5.7	4.6	2.5
7.....	4.7	8.3	14.2	13.6	8.9	5.2	3.0	5.2	3.6	5.2	4.4	2.8
8.....	4.6	11.5	14.4	13.4	9.1	4.9	2.9	5.7	3.2	5.2	4.3	2.9
9.....	4.7	19.3	12.8	11.9	8.7	4.7	2.8	6.6	2.8	5.5	4.0	7.1
10.....	4.9	20.4	11.2	10.5	8.7	4.5	2.7	7.5	2.8	5.3	3.9	8.1
11.....	4.7	17.8	10.0	9.6	8.1	4.5	2.7	7.2	3.0	4.8	3.8	8.2
12.....	4.6	14.7	9.2	8.7	7.7	4.4	3.0	6.3	3.4	4.6	3.6	7.7
13.....	4.6	12.0	8.6	8.0	7.2	4.0	2.7	5.8	3.6	4.4	3.5	7.4
14.....	4.9	10.0	8.7	7.5	6.7	3.9	2.5	5.2	4.6	4.2	3.4	6.4
15.....	4.6	9.8	9.7	7.1	6.6	4.0	2.3	4.8	4.0	3.9	3.3	3.7
16.....	5.4	9.6	13.7	6.9	7.8	4.1	2.1	4.2	4.0	3.7	3.2	4.2
17.....	7.2	9.0	15.1	7.1	9.3	4.0	2.0	3.8	3.7	3.7	3.2	3.9
18.....	9.2	9.3	14.9	9.4	8.6	3.9	2.2	3.7	4.0	3.7	3.0	3.9
19.....	8.2	8.5	13.0	16.6	7.9	3.7	4.7	3.3	5.3	4.2	3.2	4.0
20.....	7.5	7.8	11.7	20.4	8.8	3.6	4.7	3.1	3.7	4.0	3.1	4.0
21.....	7.0	7.3	12.4	18.2	10.7	3.7	4.1	2.6	3.7	4.0	3.1	3.9
22.....	9.6	7.1	14.0	14.3	11.9	3.8	3.5	2.5	5.8	3.8	3.1	3.9
23.....	13.0	7.2	20.0	11.3	11.9	3.7	3.2	3.8	3.5	5.3	2.9	3.9
24.....	12.3	7.4	25.5	9.6	11.6	3.8	3.2	4.0	3.3	7.2	2.8	3.9
25.....	11.7	12.1	27.2	8.7	9.2	4.0	4.1	3.3	3.4	8.8	2.8	4.3
26.....	10.0	18.7	26.0	8.4	7.8	4.0	5.9	3.8	4.0	9.2	2.7	4.6
27.....	8.3	26.4	21.4	8.4	7.4	3.9	7.5	3.6	4.3	9.5	2.6	9.4
28.....	7.3	34.8	15.4	8.5	8.0	3.9	7.7	3.0	4.0	8.6	2.6	12.5
29.....	6.6	.....	13.0	8.4	8.1	3.5	7.0	3.8	3.8	7.6	2.5	12.9
30.....	7.7	.....	11.9	8.1	7.4	3.1	6.3	5.4	5.3	7.1	2.4	12.4
31.....	8.3	.....	10.7	.....	6.8	.....	6.2	6.5	.....	7.0	.....	9.3

Tennessee River at Chattanooga, Tennessee, for 1891.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.7	9.8	18.6	15.4	5.9	5.8	3.9	8.3	5.4	1.8	1.3	3.7
2	7.8	13.2	17.5	16.3	5.7	5.6	3.8	10.3	4.7	1.9	1.3	3.2
3	9.9	16.1	15.6	16.3	5.6	5.3	3.6	15.1	4.3	1.9	1.3	2.9
4	14.1	19.8	13.3	15.7	5.5	4.8	3.6	16.4	4.2	1.8	1.2	2.8
5	15.5	22.6	15.4	15.1	5.2	4.4	3.6	12.0	5.1	1.8	1.2	5.6
6	15.2	21.6	20.0	12.6	5.1	4.1	3.6	8.7	5.1	1.7	1.2	6.1
7	10.4	18.3	23.6	11.6	4.9	3.9	3.4	6.9	5.2	1.7	1.2	6.6
8	8.2	16.9	29.1	10.8	4.7	4.1	3.4	5.8	5.2	1.6	1.2	8.6
9	7.1	14.5	34.5	9.8	4.6	4.6	3.3	5.1	5.8	1.7	1.2	10.8
10	6.3	21.0	37.5	9.6	4.5	4.7	4.5	4.6	4.9	1.7	1.2	10.9
11	6.5	27.8	38.9	9.8	4.4	5.5	5.1	4.4	4.4	1.8	1.5	10.2
12	8.9	34.3	37.6	9.9	4.3	7.0	4.4	4.0	3.9	1.8	1.7	8.5
13	10.7	36.5	33.5	10.6	4.2	6.5	3.9	4.0	3.6	1.7	2.7	6.8
14	10.0	37.5	27.0	11.3	4.1	5.7	3.5	3.9	3.5	1.7	3.6	5.7
15	9.2	35.5	22.2	12.2	4.2	5.5	3.1	3.8	3.5	1.7	4.1	5.1
16	7.3	29.0	19.8	10.8	4.2	5.7	2.9	3.6	3.5	1.6	3.5	5.0
17	7.8	21.1	18.1	9.4	4.5	5.8	2.8	3.5	3.5	1.6	2.8	5.2
18	7.5	19.7	15.3	8.4	4.7	6.1	2.7	3.4	3.2	1.5	2.5	5.3
19	7.5	18.2	13.5	8.2	4.7	6.8	4.1	3.0	2.9	1.5	2.4	4.8
20	7.6	16.5	12.3	7.9	4.6	7.3	5.0	3.0	2.7	1.5	2.5	4.5
21	7.3	15.5	11.3	7.9	4.5	6.8	4.5	3.4	2.6	1.5	2.3	4.2
22	8.2	18.8	10.8	7.6	4.3	6.8	4.0	4.0	2.5	1.5	2.4	4.0
23	12.5	24.0	10.7	7.4	4.1	6.5	3.8	4.6	2.4	1.5	3.0	3.8
24	15.3	27.7	10.8	7.4	4.0	7.1	3.6	5.5	2.3	1.5	4.6	3.7
25	14.0	29.0	10.6	7.5	3.8	7.4	3.5	5.6	2.2	1.5	6.2	4.1
26	13.6	26.7	10.4	7.5	3.9	7.6	3.5	7.7	2.2	1.5	6.7	4.9
27	11.2	20.6	10.5	7.4	4.0	6.2	3.5	8.2	2.1	1.5	6.3	8.1
28	9.7	19.0	14.1	7.2	4.1	4.9	3.6	8.1	2.0	1.5	5.6	10.2
29	7.9	.....	13.6	6.5	4.1	4.3	3.7	7.0	1.9	1.4	4.7	9.6
30	7.9	.....	13.0	6.2	4.7	4.1	3.8	6.4	1.9	1.4	4.0	8.4
31	8.9	.....	13.1	.....	5.3	.....	5.7	6.1	.....	1.4	.....	7.8

Tennessee River at Chattanooga, Tennessee, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.6	6.5	5.7	9.1	8.7	5.6	6.6	4.2	2.1	2.2	1.1	4.1
2	6.6	6.2	5.6	8.3	8.2	5.4	5.6	4.1	1.8	2.0	1.2	4.0
3	8.1	6.0	5.5	7.4	7.6	5.5	5.5	4.2	1.7	1.9	1.2	3.8
4	8.8	5.8	5.3	6.8	7.3	5.8	5.4	4.0	1.5	1.8	1.6	3.7
5	8.7	5.5	5.1	6.5	7.4	8.8	6.6	4.1	1.3	1.7	2.0	3.6
6	8.4	5.4	5.0	8.5	7.0	9.2	8.9	4.9	2.2	1.6	2.3	3.6
7	9.0	5.3	4.9	21.7	6.6	9.3	11.2	4.2	2.1	1.6	2.4	3.3
8	9.8	5.8	5.0	31.6	6.3	8.7	11.8	3.8	2.0	1.5	2.4	3.2
9	10.0	8.1	6.0	34.2	6.2	8.6	10.1	3.5	2.0	1.5	2.9	3.2
10	9.3	11.5	7.1	34.3	5.9	8.3	8.6	3.3	1.9	1.5	4.4	3.0
11	8.1	11.3	8.0	31.0	5.5	7.8	9.0	3.3	2.0	1.5	5.9	2.9
12	8.3	10.5	7.9	26.6	5.7	8.0	9.5	3.1	1.8	1.5	6.6	2.7
13	11.2	8.9	7.6	18.0	5.7	8.1	9.4	3.5	2.1	1.4	7.0	2.6
14	22.9	7.7	7.6	12.9	5.5	7.8	8.9	3.6	2.1	1.4	4.4	2.6
15	32.9	7.2	6.8	11.7	5.3	6.0	8.7	3.7	2.1	1.4	4.2	3.3
16	37.1	7.4	6.2	10.9	5.2	5.3	8.5	3.5	3.1	1.4	4.8	3.4
17	37.9	8.0	5.9	10.0	5.1	4.8	8.4	3.1	4.5	1.4	5.6	5.3
18	35.2	7.9	6.5	9.4	4.8	4.4	8.1	2.9	4.1	1.3	6.2	8.1
19	26.3	7.5	7.5	8.8	5.1	4.4	7.5	2.8	3.5	1.3	6.4	8.7
20	18.7	7.7	8.2	12.3	5.5	4.3	7.2	2.8	3.0	1.2	6.2	8.4
21	19.0	7.9	8.2	16.2	6.1	7.0	6.9	3.0	2.8	1.2	5.5	9.1
22	19.0	8.9	7.8	16.3	6.5	7.8	6.2	2.9	3.0	1.2	4.8	9.3
23	17.4	8.9	7.6	15.5	6.9	7.4	5.6	2.9	2.6	1.2	4.4	8.9
24	14.9	8.4	8.4	14.8	7.1	7.1	5.4	3.0	2.3	1.2	4.2	7.8
25	12.2	7.9	9.6	13.5	7.6	6.9	5.2	2.7	2.3	1.2	3.9	6.7
26	10.5	7.5	9.5	13.7	7.8	6.8	5.0	2.8	3.6	1.1	3.4	5.8
27	9.7	6.7	10.0	13.6	6.7	6.7	4.6	3.2	3.6	1.1	3.1	5.2
28	8.5	6.4	10.6	10.4	6.2	7.3	4.5	3.6	3.1	1.1	3.0	4.8
29	7.7	5.9	10.3	9.1	5.8	7.5	4.3	4.4	2.6	1.1	3.0	4.3
30	6.9	.....	9.7	8.8	5.7	7.2	4.1	3.8	2.4	1.1	3.6	3.9
31	6.8	.....	9.4	.....	5.6	.....	3.8	3.3	.....	1.1	.....	3.3

Tennessee River at Chattanooga, Tennessee, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.4	10.4	8.4	5.5	10.2	7.4	3.9	2.6	8.4	2.6	3.1	2.5
2	3.8	12.1	9.1	5.3	9.6	8.0	3.8	2.5	6.8	2.5	3.0	3.9
3	4.7	10.6	8.9	5.1	11.0	10.0	4.2	3.1	5.0	2.4	2.8	3.7
4	5.7	8.6	8.9	5.1	18.4	8.1	5.2	3.5	6.2	2.4	2.7	4.1
5	5.6	8.0	8.7	5.1	24.5	6.6	4.8	3.3	6.0	2.6	2.6	4.3
6	5.3	7.7	9.0	5.2	28.2	8.3	3.9	3.2	4.9	2.5	2.5	4.7
7	5.2	7.0	9.1	5.4	30.0	16.0	3.8	4.9	4.3	2.9	2.4	4.7
8	4.7	6.5	8.8	5.4	28.2	20.7	3.5	5.0	3.5	3.1	2.4	4.5
9	4.0	6.1	8.8	5.1	18.0	19.1	3.4	4.1	3.2	2.9	2.3	4.1
10	3.8	6.2	9.4	5.1	12.8	15.2	3.6	3.8	2.8	2.9	2.4	4.0
11	3.4	8.5	11.1	5.1	11.7	11.8	3.4	3.3	2.8	2.6	2.5	3.7
12	2.9	14.7	11.7	5.0	10.4	8.9	3.4	3.0	3.7	2.5	4.8	3.2
13	2.9	21.8	11.5	4.8	9.4	7.3	3.3	2.7	5.8	2.4	3.8	3.1
14	(a)	23.6	12.0	10.2	8.8	6.8	3.2	2.5	10.9	2.5	3.6	3.0
15	(a)	22.6	10.6	12.1	8.1	6.5	3.0	2.8	12.7	2.0	3.5	2.9
16	(a)	21.3	9.5	10.4	7.8	6.2	2.8	2.9	9.6	1.7	3.0	3.0
17	(a)	23.6	8.4	8.6	9.4	5.6	2.7	3.8	8.0	9.6	2.8	3.2
18	(a)	29.4	7.6	7.4	10.4	5.4	2.8	5.2	7.0	6.4	2.7	3.5
19	(a)	32.4	7.0	6.5	8.9	5.3	3.0	4.9	6.1	5.7	2.5	3.8
20	(a)	33.4	6.7	6.4	7.7	5.2	3.2	4.0	5.1	5.2	2.6	3.9
21	(a)	32.8	6.3	7.2	7.4	5.4	3.5	2.9	4.2	4.1	2.6	3.9
22	(a)	28.5	6.0	7.2	6.7	5.6	3.6	2.6	3.6	3.4	2.6	3.5
23	2.9	18.2	5.8	7.1	6.1	5.7	4.6	2.4	3.4	3.1	2.5	3.3
24	3.1	12.3	5.7	6.8	5.7	5.4	5.2	2.3	3.2	2.8	2.5	3.1
25	3.1	10.4	6.4	6.7	5.4	5.9	5.5	2.2	3.0	3.1	2.4	2.9
26	3.4	9.3	6.8	6.0	5.2	5.6	3.7	1.9	2.9	3.3	2.5	2.8
27	3.7	8.4	6.8	5.7	5.0	5.2	3.4	1.8	2.7	4.9	2.6	2.7
28	3.8	8.2	6.3	7.0	4.6	5.1	2.9	1.6	2.6	4.6	2.8	2.6
29	4.4	.....	5.9	9.5	5.4	4.7	3.7	1.6	2.4	4.0	2.7	2.5
30	5.3	.....	5.8	10.4	6.5	4.1	2.6	1.7	2.5	3.5	2.5	2.7
31	7.1	.....	5.7	.....	7.4	.....	2.6	1.6	.....	3.2	.....	3.1

a Frozen at gage.

Tennessee River at Chattanooga, Tennessee, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.9	5.1	7.7	5.0	3.9	3.8	4.4	2.9	4.0	0.9	1.4	1.0
2	3.4	5.0	8.2	4.8	3.8	3.6	4.0	2.9	3.8	.9	1.7	1.0
3	3.8	4.9	9.4	5.4	3.7	3.5	3.7	2.9	3.0	1.0	2.3	.9
4	3.9	5.5	9.7	5.3	3.7	3.4	4.4	2.8	2.6	1.5	1.6	.9
5	3.5	21.9	9.5	6.8	3.6	3.3	4.2	2.9	2.1	1.8	1.4	.9
6	3.1	25.5	9.3	6.9	3.5	3.2	3.7	3.0	2.0	1.8	1.5	.9
7	4.9	23.9	8.5	7.2	3.4	2.9	3.2	2.9	1.8	1.5	1.5	.9
8	6.1	19.7	8.2	7.4	3.3	2.8	3.3	2.9	1.7	1.3	1.3	.9
9	9.3	16.1	7.9	6.6	3.4	2.6	3.1	3.0	1.5	1.1	1.2	1.1
10	9.0	16.0	7.2	5.7	3.3	2.5	3.3	2.6	1.4	1.0	1.1	1.2
11	8.5	16.7	6.9	5.9	3.2	2.5	3.7	2.3	1.4	.8	1.0	1.6
12	7.9	15.4	6.6	7.2	4.7	2.4	3.3	2.1	1.4	.9	1.0	3.8
13	8.3	15.2	6.7	8.5	5.1	2.3	2.7	1.9	1.3	1.2	.9	8.6
14	8.0	14.1	7.2	7.8	4.8	2.3	2.4	1.8	1.2	1.9	.8	11.1
15	7.8	12.2	7.0	7.2	4.3	2.2	2.1	2.0	1.5	2.4	.8	11.2
16	7.8	10.3	6.9	6.7	4.0	2.1	1.9	3.6	1.8	2.1	.8	10.8
17	7.1	9.5	6.8	6.3	4.1	2.0	1.8	4.6	1.8	1.7	.8	8.6
18	7.2	8.6	7.3	5.5	5.2	2.1	2.8	3.5	2.0	1.4	.7	6.6
19	6.3	8.4	7.4	5.0	5.0	2.4	2.4	3.0	2.0	1.1	.8	4.7
20	6.0	8.3	7.7	5.1	5.4	2.5	2.4	3.1	1.6	1.0	.9	4.2
21	5.3	8.5	7.1	4.9	5.6	2.6	3.3	3.6	1.5	.9	.9	3.6
22	5.0	8.7	8.8	4.8	6.2	2.5	3.7	3.7	1.5	.8	.9	3.2
23	5.0	8.8	8.7	4.7	6.8	2.3	3.8	4.0	1.8	.8	1.0	2.8
24	5.2	8.2	8.1	4.6	6.9	2.2	3.4	3.6	1.8	.8	1.0	2.7
25	5.3	7.9	7.7	4.5	7.1	2.2	4.0	3.0	1.6	.8	1.1	2.5
26	5.2	7.6	7.3	4.3	6.7	2.5	1.4	2.6	1.3	.8	1.2	2.4
27	5.4	7.7	7.0	4.2	6.0	2.6	3.9	2.2	1.1	.7	1.2	4.2
28	5.4	7.7	6.5	4.1	5.6	2.7	3.8	2.7	1.0	.7	1.1	6.9
29	5.1	.....	5.9	4.0	5.1	2.9	3.6	2.4	.9	.7	1.1	8.4
30	5.0	.....	5.7	4.0	4.7	4.3	3.3	2.7	.8	1.0	1.1	7.9
31	4.9	.....	5.2	.....	4.2	.....	3.3	4.3	.....	1.1	.....	5.8

Tennessee River at Chattanooga, Tennessee, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.7	7.6	6.8	7.8	6.0	5.6	3.2	4.4	3.3	0.9	1.1	1.4
2	3.9	7.2	7.3	7.4	5.8	5.2	3.4	4.1	3.4	.8	1.2	1.5
3	3.3	7.3	12.1	6.8	5.5	4.8	3.8	3.8	3.2	.8	1.3	1.4
4	3.2	7.5	18.2	6.5	5.4	4.5	4.0	3.5	3.1	.8	1.6	1.4
5	3.1	7.6	19.9	6.3	5.7	4.2	4.5	3.4	2.9	.8	1.6	1.4
6	3.1	7.4	18.2	6.2	6.0	4.4	5.0	3.0	2.8	.8	1.3	1.6
7	3.3	6.9	13.4	6.0	6.5	4.6	5.0	3.2	2.8	.8	1.3	1.5
8	4.0	6.5	10.5	9.6	7.0	5.2	5.1	3.3	2.8	.9	1.2	1.4
9	10.9	6.4	9.2	10.7	8.2	5.1	5.5	3.3	2.5	.8	1.1	1.3
10	20.5	5.0	8.6	11.4	8.6	4.6	5.7	3.0	2.4	.9	1.2	1.3
11	28.5	4.0	8.1	13.0	9.0	4.2	5.1	3.0	2.3	1.0	1.3	1.4
12	32.1	3.3	7.5	12.5	8.8	3.8	4.4	2.9	2.4	1.0	1.7	1.5
13	31.2	4.2	7.8	10.4	8.9	3.6	3.8	3.2	2.5	1.0	2.1	1.8
14	28.3	(a)	8.0	8.8	9.5	3.5	3.4	2.9	2.4	1.0	2.4	1.9
15	19.5	4.3	8.7	7.9	9.0	3.4	3.2	2.8	2.3	.9	2.2	2.0
16	12.3	4.7	9.4	7.4	8.2	3.4	3.2	2.7	2.2	1.0	2.0	1.9
17	10.9	4.7	9.2	7.0	7.7	3.8	3.7	3.1	2.1	1.0	1.9	1.8
18	10.0	4.2	9.6	9.0	7.1	3.7	3.6	4.3	2.3	1.0	1.8	1.7
19	9.7	4.7	9.4	11.8	7.0	3.5	3.3	4.9	2.2	.9	1.7	1.6
20	9.1	4.6	8.9	11.8	7.2	3.2	3.0	5.7	2.0	.9	1.5	1.5
21	9.6	5.1	14.3	9.9	7.1	3.1	2.7	5.3	2.1	.8	1.3	1.6
22	10.2	5.6	20.6	8.6	6.7	3.2	2.7	6.1	1.9	.8	1.1	2.1
23	9.9	6.1	22.7	7.7	6.5	3.1	2.5	5.3	1.6	.7	1.3	3.3
24	9.1	6.7	22.0	7.1	5.8	3.0	2.4	4.8	1.4	.7	1.4	4.2
25	10.8	6.8	18.2	6.7	5.6	2.9	2.4	4.6	1.3	.7	1.3	4.6
26	10.8	6.5	13.0	6.3	5.6	2.9	2.9	4.7	1.3	.7	1.3	4.3
27	10.0	6.3	11.3	6.0	7.0	2.6	3.8	4.2	1.2	.7	1.3	4.2
28	9.3	6.3	10.6	6.0	7.5	2.5	10.2	3.7	1.1	.7	1.3	4.5
29	8.8	.....	9.5	5.9	7.4	2.5	10.4	3.5	1.0	.7	1.3	5.2
30	8.6	.....	8.9	5.9	6.7	2.6	7.4	3.7	0.9	.7	1.5	4.7
31	8.4	.....	8.4	.....	6.0	.....	5.3	3.4	.....	1.0	.....	4.7

a Frozen.

Tennessee River at Chattanooga, Tennessee, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.9	4.4	4.1	14.8	3.4	2.6	3.3	5.5	2.4	2.5	1.2	2.4
2	5.0	6.2	3.9	27.7	3.4	3.0	3.2	5.2	2.1	2.3	1.2	2.5
3	4.9	10.0	3.8	34.4	3.4	4.4	3.1	4.8	1.9	2.6	1.3	2.5
4	4.9	11.6	3.7	38.8	3.5	5.7	3.2	4.6	1.8	3.0	1.5	2.6
5	4.7	10.5	3.6	40.5	4.0	5.2	3.3	4.5	1.6	2.7	1.5	2.6
6	4.3	9.3	3.5	36.9	4.6	4.7	3.2	4.9	1.6	2.6	1.6	2.7
7	3.6	11.8	3.4	23.3	4.6	4.1	3.6	5.0	1.5	2.1	2.3	2.9
8	3.3	14.0	3.5	11.6	4.3	3.5	5.0	4.2	2.0	1.7	3.5	3.0
9	3.2	13.8	3.5	9.0	4.0	3.5	3.9	3.8	2.8	1.5	4.2	2.8
10	3.2	13.2	3.4	8.0	3.7	4.5	14.2	3.4	2.7	1.4	4.1	2.8
11	3.1	12.8	3.6	7.2	3.4	7.0	21.1	3.3	2.4	1.2	3.3	2.7
12	3.1	11.4	3.6	6.7	3.1	6.3	21.6	3.4	2.0	1.2	3.2	2.6
13	2.9	10.1	3.8	6.2	2.9	5.1	15.6	3.2	1.8	1.2	5.8	2.4
14	2.7	11.1	3.8	5.8	2.8	4.3	11.5	3.2	1.6	1.2	7.3	2.6
15	2.6	12.8	3.7	5.5	2.7	3.6	11.2	3.1	1.6	1.5	6.5	4.1
16	2.4	13.6	3.8	5.2	2.6	3.2	11.4	3.0	1.5	1.7	5.5	6.5
17	2.3	12.5	5.5	5.0	2.5	3.0	11.0	3.0	1.3	1.6	4.9	6.6
18	2.3	11.0	10.1	4.8	2.4	2.8	13.9	2.9	1.4	1.6	4.3	6.3
19	2.3	9.0	13.1	4.2	2.4	2.9	12.5	2.7	1.4	1.7	3.8	6.4
20	2.3	7.6	15.7	4.4	2.2	3.1	9.6	2.6	1.3	1.6	3.4	6.8
21	2.3	6.7	13.8	4.2	2.1	3.7	7.6	2.4	1.2	1.6	3.0	7.0
22	2.5	6.0	11.2	4.1	2.1	3.5	6.5	2.4	1.2	1.4	2.8	7.2
23	3.1	5.4	9.5	4.1	2.5	3.5	8.5	2.2	1.3	1.2	2.5	7.3
24	5.0	4.9	8.4	4.0	3.2	3.3	8.8	2.2	1.4	1.2	2.4	7.0
25	6.5	4.7	7.9	4.0	3.6	3.1	8.6	2.8	1.6	1.2	2.3	6.6
26	8.2	4.6	7.5	3.8	3.8	2.9	7.8	2.6	2.0	1.2	2.2	5.9
27	8.0	4.5	7.2	3.8	3.2	2.6	11.1	2.7	1.7	1.2	2.1	5.3
28	7.0	4.4	6.7	3.8	3.1	2.6	12.2	3.2	1.5	1.2	2.2	4.8
29	6.0	4.2	6.2	3.6	2.8	2.8	9.3	4.0	1.5	1.1	5.3	4.4
30	5.3	.....	5.8	3.6	2.7	3.0	7.2	3.6	2.7	1.1	9.4	3.7
31	4.8	.....	7.7	.....	2.5	.....	6.2	2.8	.....	1.3	.....	3.0

Missouri River at Townsend, Montana.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	92.3	91.6	88.8	88.9	89.5	91.8	92.0	89.1	88.9	88.9	89.0	91.5
2	92.2	91.6	90.9	88.9	89.5	92.2	92.0	89.1	89.0	88.9	89.0	91.8
3	91.8	91.6	90.7	88.9	89.5	92.6	91.8	89.1	88.9	88.9	88.9	92.2
4	91.4	91.6	90.7	88.9	89.5	93.0	91.6	89.1	88.9	88.9	88.9	92.8
5	91.4	91.6	90.7	88.9	89.6	93.6	91.4	89.1	88.9	88.9	88.9	92.9
6	91.6	91.6	90.7	88.9	89.7	93.7	91.2	89.1	88.9	88.9	88.9	92.9
7	91.6	91.6	90.7	88.9	89.8	93.8	91.0	89.1	88.9	88.9	88.9	92.9
8	91.6	91.6	90.7	89.0	89.9	93.7	91.0	89.1	88.9	88.9	88.9	92.9
9	91.8	91.6	90.7	89.0	90.0	93.8	90.7	89.1	88.9	88.9	89.0	92.9
10	91.8	91.5	90.7	89.0	90.0	93.9	90.6	89.1	89.0	88.9	89.0	92.9
11	92.0	91.5	90.7	89.0	89.9	94.2	90.4	89.1	89.1	89.0	89.1	92.9
12	91.9	91.5	92.2	89.0	89.8	94.5	90.4	89.0	89.1	88.9	89.1	92.9
13	91.9	91.5	90.0	88.9	89.8	94.4	90.5	88.9	89.1	88.9	89.2	92.8
14	91.9	91.5	89.4	88.9	89.7	94.4	90.6	88.9	89.1	88.9	89.2	92.8
15	91.9	91.5	89.0	88.9	89.6	94.5	90.8	88.9	89.1	88.9	89.2	92.6
16	91.9	91.5	88.8	88.9	89.6	94.6	90.6	88.9	89.1	88.9	89.2	92.2
17	91.9	91.5	88.6	88.9	89.6	94.7	90.5	88.9	89.1	88.9	89.2	91.9
18	91.9	91.5	88.6	88.9	89.7	94.8	90.2	88.9	89.0	88.9	89.1	91.4
19	91.8	91.5	88.8	88.9	89.7	94.8	90.0	88.8	89.0	88.9	89.1	91.4
20	91.8	91.5	89.0	88.9	89.8	94.9	89.8	88.8	89.0	88.9	89.1	91.4
21	91.8	91.5	89.1	89.0	89.8	94.7	89.7	88.8	89.0	88.9	89.1	89.8
22	91.8	90.5	89.1	89.0	89.8	94.6	89.7	88.8	89.1	88.9	89.1	89.7
23	91.8	90.4	89.1	89.1	90.0	94.5	89.7	88.8	89.1	88.8	89.1	89.5
24	91.8	90.3	89.1	89.1	90.0	94.2	89.6	88.8	89.1	88.8	89.1	89.3
25	91.8	89.8	89.1	89.1	90.2	93.8	89.6	88.8	89.1	88.8	89.1	89.3
26	91.8	89.6	89.1	89.1	90.4	93.4	89.5	88.8	89.1	88.8	90.6	89.2
27	91.7	89.2	89.1	89.2	90.4	92.8	89.4	88.7	89.1	88.8	90.6	89.2
28	91.7	88.4	89.1	89.2	90.6	92.6	89.4	88.7	89.0	88.9	90.6	89.1
29	91.7	88.8	89.0	89.4	91.1	92.4	89.3	88.7	88.9	88.9	90.6	89.0
30	91.6	.....	88.9	89.5	91.5	92.2	89.3	88.7	88.9	89.0	90.8	88.9
31	91.6	.....	88.9	.....	91.6	.....	89.2	88.8	.....	89.0	.....	88.9

West Gallatin River, near Salesville, Montana.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.60	2.90	2.70	.....	3.25	5.45	5.55	3.60	3.40	3.40	3.10
2	3.70	2.90	2.60	.....	3.25	6.05	5.45	3.70	3.40	3.40	3.10
3	3.60	2.90	2.70	.....	3.30	5.95	5.30	3.80	3.40	3.40	3.10
4	3.50	2.90	2.70	.....	3.45	5.85	5.15	3.75	3.40	3.35	3.10
5	3.85	2.90	2.80	.....	3.45	5.65	5.05	3.70	3.40	3.40	3.10
6	3.90	2.90	2.80	.....	3.45	5.60	4.95	3.70	3.30	3.40	3.10
7	4.00	2.90	2.85	.....	3.40	5.60	4.95	3.70	3.30	3.30	3.05
8	3.75	2.90	.....	.....	3.35	6.00	4.85	3.70	3.30	3.35	3.05
9	3.40	2.90	.....	.....	3.35	6.95	4.75	3.65	3.30	3.45	3.15
10	3.10	2.90	.....	3.00	3.35	7.85	4.70	3.55	3.30	3.50	3.20
11	3.00	3.00	.....	3.00	3.35	7.10	4.70	3.50	3.40	3.40	3.10
12	2.90	3.00	.....	3.00	3.35	6.65	4.75	3.50	3.40	3.30	3.10
13	2.90	3.00	.....	2.90	3.30	6.75	4.85	3.50	3.40	3.30	3.15
14	2.90	3.00	.....	3.00	3.30	7.15	4.75	3.50	3.45	3.30	3.20
15	3.00	3.00	.....	2.90	3.30	7.20	4.60	3.50	3.45	3.30	3.20
16	3.00	3.00	.....	2.90	3.30	7.50	4.45	3.50	3.40	3.30	3.20
17	3.00	3.00	.....	2.90	3.20	7.50	4.30	3.50	3.40	3.20	3.20
18	3.00	3.00	.....	2.90	3.20	7.90	4.25	3.50	3.40	3.20	3.10
19	3.00	3.00	.....	2.90	3.20	7.85	4.20	3.50	3.40	3.20	3.10
20	2.90	3.00	.....	2.90	3.25	7.35	4.10	3.40	3.40	3.20	3.10
21	2.90	3.10	.....	2.90	3.30	6.95	4.00	3.50	3.30	3.20	3.05
22	2.90	3.10	.....	3.00	3.40	6.50	4.00	3.45	3.30	3.20	3.20
23	3.00	2.95	.....	3.00	3.50	6.20	4.00	3.40	3.30	3.20	3.20
24	3.00	2.95	.....	3.00	4.10	6.00	3.90	3.40	3.30	3.20	3.10
25	3.00	2.95	.....	3.15	4.10	5.90	3.90	3.40	3.50	3.20	3.00
26	3.00	3.00	.....	3.20	4.00	5.85	3.80	3.35	3.45	3.20	2.80
27	2.90	2.95	.....	3.20	4.10	5.80	3.70	3.30	3.40	3.20	2.70
28	2.90	2.90	.....	3.30	4.40	5.55	3.70	3.30	3.40	3.20	2.70
29	2.90	2.75	.....	3.30	4.40	5.50	3.85	3.30	3.30	3.10	2.70
30	2.90	.....	.....	3.30	3.90	5.50	3.70	3.30	3.40	3.10	2.70
31	2.90	.....	.....	.....	4.90	.....	3.60	3.40	.....	3.10	.....

Middle Creek at Bozeman, Montana.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1							
2		0.25					
3				0.90			
4	0.10		0.90				
5						0.20	
6							
7				1.05			
8			1.15		0.35		
9		.33					
10							
11					.30		
12			1.29			.28	
13							
14						.27	
15				.88			
16		.25	1.30				
17					.28		0.21
18						.22	
19				.60		.21	
20							
21							
22		.48				.20	
23			1.10				
24	.20	.80					
25					.23		
26							
27		.93					
28					.22		
29				.43			
30		1.80					
31							

Gallatin River at Logan, Montana.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	1.00	.....	1.30	3.20	2.75	1.20	1.00	1.00	.....	.....
2	(a)	.90	.....	1.20	3.65	2.65	1.10	1.00	1.00	.....	.....
3	(a)	.90	.....	1.20	3.80	2.50	1.10	1.00	1.00	.....	.....
4	(a)	1.00	.....	1.20	3.95	2.50	1.10	1.00	1.05	1.00	.....
5	(a)	.90	.....	1.40	3.80	2.35	1.10	1.00	1.10	.....	.....
6	(a)	.90	.....	1.55	3.75	2.20	1.10	.90	1.05	.....	.....
7	(a)	1.00	.....	1.50	3.75	2.00	1.10	.90	1.00	1.00	.....
8	(a)	1.05	.....	1.45	3.70	1.90	1.10	.90	1.00	.....	.....
9	(a)	1.00	1.10	1.50	4.20	1.80	1.10	.90	1.00	.....	.....
10	(a)	1.00	1.10	1.60	5.10	1.65	1.05	1.00	1.00	.....	.....
11	(a)	1.20	1.10	1.50	5.15	1.50	1.00	1.10	1.00	1.00	1.63
12	(a)	.95	1.05	1.50	4.50	1.50	1.00	1.20	1.00	.....	1.10
13	(a)	.90	1.00	1.50	4.50	1.75	1.00	1.10	1.00	.....	.....
14	(a)	.90	1.10	1.40	4.65	1.60	1.00	1.05	1.00	1.00	.....
15	(a)	.90	1.10	1.40	4.75	1.70	1.00	1.00	1.00	.....	.....
16	(a)	.90	1.10	1.30	5.20	1.60	1.00	1.00	.95	.....	1.10
17	(a)	.90	1.00	1.30	5.45	1.50	1.00	1.00	.95	.....	.....
18	(a)	.90	1.00	1.30	5.60	1.40	1.00	1.00	1.00	1.00	.....
19	(a)	.90	1.00	1.30	5.10	1.40	1.00	.95	1.00	.....	1.10
20	(a)	.90	1.00	1.30	4.85	1.40	1.00	.95	1.00	.....	.....
21	(a)	1.00	1.00	1.30	4.50	1.40	1.00	.95	1.00	1.00	.....
22	(a)	.95	1.00	1.30	4.40	1.30	1.00	.95	1.00	.....	.....
23	(a)	.90	1.00	1.30	4.25	1.30	1.00	.95	.95	.....	.....
24	(a)	.95	1.00	1.35	4.05	1.20	1.00	.95	1.00	1.00	1.00
25	(a)	1.00	1.05	1.70	3.80	1.10	1.00	1.10	1.00	.....	.....
26	(a)	1.00	1.10	1.80	3.55	1.10	1.00	1.15	1.00	.....	1.00
27	(a)	1.00	1.10	1.80	3.40	1.10	1.00	1.05	1.00	.....	.....
28	1.10	1.00	1.20	2.05	3.25	1.10	1.00	1.05	1.00	.....	.....
29	1.10	1.00	1.20	2.30	3.10	1.20	1.00	1.05	1.00	.....	.....
30	1.10	.....	1.20	2.50	2.95	1.20	1.00	1.00	1.00	.....	.....
31	1.00	.....	.....	2.70	.....	1.20	1.00	.....	1.00	.....	.....

a Frozen.

Madison River at Threeforks, Montana.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.00	1.10	.....	0.30	1.35	2.10	0.80	0.50	0.45
2	.90	1.10	.....	.30	1.45	2.00	.80	.50	45
3	— .60	1.00	.....	.30	1.55	1.90	.70	.50	.48
4	— .60	1.00	.....	.30	1.75	1.85	.70	.50	.50
5	— .60	.90	.....	.30	1.95	1.80	.70	.50	.50
6	— .60	.90	.....	.30	2.05	1.70	.70	.50	.50
7	— .45	.90	.....	.30	1.95	1.60	.60	.50	.50
8	— .35	.90	0.20	.35	1.95	1.50	.60	.50	.50
9	— .95	.90	.20	.40	2.30	1.45	.60	50	.48
10	+1.20	.90	.20	.40	2.55	1.40	.60	.50	.45
11	1.20	.80	.20	.30	2.65	1.30	.60	.50	.45
12	1.15	.80	.15	.30	2.75	1.35	.60	.53	.45
13	1.05	.80	.10	.30	2.70	1.35	.50	.55	.45
14	1.00	.80	.15	.30	2.75	1.30	.50	.55	.45
15	1.00	.80	.20	.25	2.80	1.30	.50	.55	.45
16	1.00	.80	.20	.20	2.95	1.30	.50	.50	.45
17	1.00	.80	.20	.20	3.05	1.30	.50	.50	.45
18	1.10	.80	.20	.20	3.15	1.20	.50	.45	.45
19	1.20	.80	.20	.20	3.20	1.15	.50	.45	.45
20	1.20	.80	.20	.25	3.10	1.10	.50	.45	.45
21	1.20	.80	.20	.30	3.10	1.05	.45	.45	.45
22	1.20	.80	.15	.35	3.00	1.00	.40	.45	.45
23	1.20	.80	.10	.40	2.85	.90	.40	.45	.45
24	1.20	.90	.10	.45	2.70	.90	.40	.45	.45
25	1.20	.90	.10	.55	2.55	.80	.40	.48	.45
26	1.20	.90	.20	.70	2.45	.80	.40	.50	.45
27	1.20	.90	.20	.75	2.40	.80	.40	.50	.45
28	1.20	.90	.20	.85	2.30	.70	.40	.50	.45
29	1.20	.80	.25	.95	2.20	.75	.40	.50	.40
30	1.10	.....	.30	1.05	2.15	.80	.40	.50	.40
31	1.10	.....	.....	1.20	.....	.80	.40	.....	.40

Jefferson River at Sappington, Montana.

Day.	Jan.	Sept.	Oct.	Nov.	Dec.	Day.	Jan.	Sept.	Oct.	Nov.	Dec.
1	(a)	.....	0.87	.....	.....	17	(a)	0.98	0.89	.....	.....
2	(a)	.....	.90	.....	.....	18	(a)	.97	.89	.....	2.10
3	(a)	.....	.89	0.96	.....	19	0.50	.90	.88	.....	.....
4	(a)	.....	.90	.....	.....	20	1.00	.90	.87	.....	.....
5	(a)	.....	.90	.....	.....	21	1.50	.87	.86	1.20	.....
6	(a)	.....	.90	.....	.....	22	1.00	.85	.87	.....	2.10
7	(a)	.....	.90	.81	.....	23	.....	.84	.87	1.20	.....
8	(a)	.....	.90	.....	.....	24	(a)	.86	.87	.....	.....
9	(a)	.....	.90	.....	.....	25	(a)	.89	.87	.....	.....
10	(a)	0.88	.90	.....	1.90	26	.....	.90	.86	.....	.....
11	(a)	.90	.90	.....	.....	27	.....	.90	.91	.....	.....
12	(a)	.92	.88	.....	.....	28	.....	.86	.93	.....	.....
13	(a)	.97	.87	.....	.....	29	.....	.84	.94	.....	.....
14	(a)	1.00	.87	.....	.....	30	.....	.86	.94	.....	.....
15	(a)	1.04	.87	.....	2.20	31	.....	.....	.93	.....	.....
16	(a)	1.00	.88	.....	.....						

a Frozen.

Little Goose Creek at Sheridan, Wyoming.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1..	1.70	1.75	0.70	12..	2.00	1.30	0.80	23..	1.50	0.75	0.80
2..	1.70	2.45	.70	13..	1.80	1.35	.80	24..	1.95	.75	.85
3..	1.70	2.30	.70	14..	1.80	1.30	.85	25..	2.10	.75	.80
4..	1.80	2.50	.75	15..	1.80	1.35	.80	26..	1.70	.75	.80
5..	1.80	2.30	.80	16..	1.60	1.10	.85	27..	1.70	.75	.80
6..	2.00	2.00	.75	17..	1.60	1.10	.80	28..	1.85	.75	.90
7..	2.30	1.80	.75	18..	1.50	.90	.95	29..	1.75	.75	.80
8..	2.00	1.75	.75	19..	1.40	.75	.80	30..	2.50	.70	.80
9..	2.20	1.90	.75	20..	1.30	.75	.80	31..	1.80	.....	.85
10..	2.40	1.95	.80	21..	1.40	.75	.80				
11..	2.00	1.60	.80	22..	1.55	.75	.80				

Big Goose Creek at Sheridan, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	2.90	3.70	2.25	2.35	1.50	17	2.60	2.00	3.15	2.10	1.90	1.50
2	.....	2.80	3.45	2.40	2.10	1.50	18	2.55	3.20	3.10	2.75	1.85	1.40
3	.....	2.80	5.10	2.40	2.20	1.60	19	2.50	3.50	3.05	2.10	1.90	1.40
4	.....	3.00	4.90	2.40	2.15	1.50	20	2.58	3.00	3.10	2.15	1.90	1.50
5	.....	3.20	4.20	2.40	2.35	1.50	21	2.55	3.00	3.15	2.30	1.90	1.60
6	.....	3.40	4.10	2.45	2.20	1.60	22	2.50	3.50	3.10	2.30	1.90	1.50
7	.....	3.20	3.75	2.30	2.15	1.70	23	2.50	3.50	2.80	2.60	1.90	1.40
8	.....	2.00	4.25	2.35	2.10	1.70	24	2.60	2.95	2.75	2.45	1.90	1.50
9	.....	3.60	4.25	2.25	2.10	1.50	25	2.60	3.90	2.80	2.35	1.80	1.40
10	2.55	3.40	4.90	2.10	2.20	1.60	26	2.75	3.10	2.70	2.25	1.80	1.50
11	2.60	3.20	4.10	2.20	1.65	1.70	27	2.85	3.45	2.65	2.40	1.80	1.60
12	2.55	3.40	3.60	2.20	1.90	1.70	28	2.95	3.50	2.65	2.40	1.80	1.50
13	2.45	.....	3.60	2.10	1.80	1.50	29	2.85	3.15	2.60	2.35	1.70	1.70
14	2.45	3.40	3.40	2.25	1.85	1.40	30	2.90	4.80	2.05	2.25	1.90	1.80
15	2.50	3.20	3.35	2.10	1.85	1.40	31	.....	4.40	.....	2.45	2.00	.....
16	2.60	3.40	3.30	2.00	1.90	1.30							

Clear Creek near Buffalo, Wyoming.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.35	0.80	1.00	0.56	.....	17	0.70	1.25	1.40	0.63	0.60	0.48
2	0.80	1.50	.80	.90	.60	.....	18	.70	1.30	1.20	.62	.62	.46
3	.80	1.90	.85	.80	.62	.....	19	.70	1.20	1.10	.68	.60	.45
4	.85	1.60	.85	.95	.66	.....	20	.75	.....	1.00	.65	.60	.....
5	1.00	1.30	.80	.90	.66	.....	21	.70	.....	.90	.68	.60	.....
6	1.05	1.20	.85	.80	.64	.....	22	.70	.....	.90	.70	.58	.....
7	1.05	1.30	.80	.70	.62	.....	23	.85	.....	.85	.68	.58	.....
8	1.10	1.30	.85	.90	.60	0.52	24	1.20	.....	.90	.62	.58	.....
9	1.00	1.70	.80	.90	.62	.54	25	1.30	.....	.90	.60	.58	.....
10	.90	1.70	.80	.75	.64	.52	26	1.20	.....	.80	.60	.58	.....
11	.80	1.45	.80	.70	.64	.50	27	1.10	.80	.80	.60	.58	.....
12	.90	1.45	.75	.68	.64	.48	28	1.10	.80	.75	.58	.58	.....
13	.90	1.30	.70	.65	.66	.48	29	1.30	.80	.75	.58	.60	.....
14	.80	1.30	.75	.65	.64	.48	30	1.70	.85	.70	.56	.62	.....
15	.70	1.25	1.20	.65	.60	.48	31	1.70	.....	1.15	.56	.....	.....
16	.70	1.25	1.50	.65	.60	.48							

Laramie River at Woods Landing, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.60	2.40	1.20	0.60	1.00	1.00
2	.....	1.55	2.28	1.10	.80	.90	1.00
3	.....	1.55	2.15	1.10	.80	.88	1.05
4	.....	1.60	2.30	1.00	.80	.80	1.00
5	.....	1.65	2.30	1.00	.80	.75	1.05
6	.....	1.95	2.05	.90	.80	.70	1.00
7	.....	2.15	1.95	.80	.70	.80	1.05
8	.....	2.25	1.85	.80	.70	.80	1.00
9	.....	2.00	1.85	.80	.75	.90	1.00
10	.....	2.00	1.90	.70	.70	1.15	1.00
11	.....	2.05	2.20	.70	.70	1.25	1.00
12	0.95	1.90	1.90	.70	.60	1.20	1.00
13	.80	1.75	1.70	.80	.60	1.05	1.00
14	1.05	1.70	1.90	.95	.60	.95	1.00
15	1.00	1.65	1.95	1.05	.60	.80	1.00
16	1.00	1.60	1.85	.85	.60	.85	.....
17	.90	1.60	1.70	1.30	.75	.85	.....
18	.80	1.70	1.65	1.15	.85	1.00	.....
19	.75	1.85	1.60	1.15	1.00	1.00	.....
20	.85	1.75	1.55	.95	1.30	1.00	.....
21	.95	1.75	1.50	.95	1.30	1.00	.....
22	1.25	1.75	1.45	.85	1.48	1.05	.....
23	1.30	1.83	1.50	1.25	1.35	1.10	.....
24	1.40	1.97	1.35	1.40	1.02	1.15	.....
25	1.60	2.02	1.35	1.30	.90	1.00	.....
26	1.75	2.15	1.35	1.40	.85	1.15	.....
27	1.85	2.00	1.30	1.40	.80	1.30	.....
28	2.05	2.10	1.20	1.25	.80	1.15	.....
29	1.65	2.10	1.20	1.00	.95	1.15	.....
30	1.75	3.25	1.20	.90	1.15	1.05	.....
31	.....	2.85	.....	.80	1.15	.....	.....

Laramie River at Uva, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.40	2.90	0.90	0.70	0.80	0.90
2	.....	1.60	4.00	.80	.70	.80	.82
3	.....	2.30	4.60	1.00	.70	.72	.82
4	.....	2.30	3.80	.90	.80	.72	.82
5	.....	2.10	3.00	.85	.80	.72	.80
6	1.80	2.00	2.70	.80	.70	.72	.80
7	1.80	2.00	2.70	.80	.70	.72	.80
8	1.75	2.10	2.80	.80	.60	.72	.80
9	1.75	2.10	2.50	.75	.70	.70	.80
10	1.60	2.30	2.30	.70	.70	.70	.80
11	1.60	2.40	2.00	.70	.80	.70	.80
12	1.50	2.40	1.50	.70	.80	.70	.80
13	1.50	2.50	1.40	.70	.70	.72	.80
14	1.60	2.50	1.40	.70	.90	.72	.80
15	1.70	2.40	1.30	.70	1.00	.72	.80
16	1.80	2.40	1.30	.80	1.00	.80	.....
17	1.70	2.20	1.20	.80	1.20	.80	.....
18	1.70	2.00	1.20	2.00	1.40	.82	.....
19	1.40	1.90	1.10	1.80	3.20	.82	.....
20	1.90	1.90	1.00	1.70	3.00	.82	.....
21	1.80	1.60	1.00	1.40	1.70	.82	.....
22	1.80	1.40	1.10	1.40	1.20	.90	.....
23	1.70	1.40	1.00	1.20	1.00	.90	.....
24	1.70	1.60	1.10	1.10	1.00	.90	.....
25	1.80	1.70	1.20	1.00	.90	.82	.....
26	1.30	1.70	1.10	1.00	.90	.82	.....
27	1.70	1.60	1.00	1.00	.90	.80	.....
28	1.70	1.50	1.00	1.00	.82	.80	.....
29	2.00	1.50	1.00	.90	.83	.80	.....
30	1.40	1.70	.90	.90	.80	.90	.....
31	.....	1.90	.....	.80	.80	.....	.....

North Platte River at Orin, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	4.67	5.70	2.13	1.68	1.20	1.17	.....
2	.....	4.45	5.97	2.03	.....	1.20	1.32	2.30
3	.....	.....	6.07	2.00	1.68	1.27	1.37	.....
4	.....	4.05	5.85	2.00	1.58	1.30	.....	.....
5	.....	4.00	5.45	.....	1.48	1.40	1.30	.....
6	.....	4.00	5.00	1.75	1.38	.....	1.27	.....
7	.....	4.17	.....	1.62	1.28	1.17	1.22	.....
8	.....	4.37	4.80	1.52	1.18	1.07	1.17	.....
9	.....	4.62	4.68	1.48	.....	1.17	1.12	1.90
10	.....	.....	4.45	1.40	1.13	1.20	1.10	.....
11	.....	5.02	4.25	1.25	.98	1.07	.....	.....
12	.....	4.86	4.08	.....	.95	.97	1.15	1.90
13	2.68	4.82	4.25	1.13	.90	.....	1.10	.....
14	3.10	4.87	.....	1.10	.90	1.23	1.10	.....
15	3.47	4.75	4.13	2.30	.83	1.30	1.10	.....
16	3.65	4.55	3.95	2.20	.....	1.35	.....	2.00
17	3.62	.....	3.75	1.78	1.05	1.42	.....	.....
18	3.45	4.05	3.55	1.65	.80	1.37	.....	.....
19	.....	3.87	3.63	.....	.90	1.27	.....	2.10
20	3.05	3.70	3.73	2.45	1.10	.....	.....	.....
21	3.00	3.50	.....	2.35	.78	1.17	.....	.....
22	2.92	3.37	3.93	2.10	.85	1.07	.....	.....
23	3.10	3.35	3.70	2.08	.....	.97	.....	.....
24	3.35	.....	3.33	1.85	.87	.95	.....	.....
25	3.60	3.42	3.05	1.73	1.95	.90	.....	.....
26	.....	3.75	2.85	.....	1.67	.90	.....	1.80
27	4.05	4.22	2.65	1.63	1.45	.....	.....	.....
28	4.40	4.60	.....	1.53	1.37	1.02	.....	.....
29	4.55	4.70	2.35	1.50	1.42	1.07	.....	.....
30	4.62	4.57	2.23	1.50	.....	1.10	.....	.....
31	.....	.....	.....	1.50	1.27	.....	.....	.....

North Platte River at North Platte, Nebraska.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.85	.....	2.70	2.75	2.55	2.20	1.50	1.90	2.45	2.40
2	2.50	2.90	.....	2.75	2.90	2.55	2.15	1.75	1.80	2.50	2.40
3	2.50	2.80	.....	2.65	2.75	2.45	2.25	1.65	1.75	2.35	2.40
4	2.50	2.80	.....	2.85	2.55	2.35	2.30	1.65	1.70	2.20	2.30
5	2.60	2.65	.....	2.95	3.85	2.25	2.05	1.60	1.75	2.15	2.30
6	2.60	2.50	.....	3.15	4.00	2.20	2.15	1.60	1.70	1.90	2.30
7	2.60	2.45	.....	3.05	3.85	2.15	2.25	1.50	1.85	1.80	2.40
8	2.60	2.05	.....	3.15	3.70	2.00	2.05	1.50	1.90	1.70	2.45
9	2.65	2.00	.....	3.00	3.55	2.00	1.80	1.60	1.85	1.85	2.55
10	2.75	2.05	2.30	2.90	3.45	1.90	1.90	1.70	1.90	1.95	2.65
11	2.80	1.95	2.45	2.90	3.35	1.80	1.70	1.80	1.80	2.05	2.65
12	2.70	2.45	2.65	2.85	3.35	1.60	1.60	1.80	1.85	2.10	2.75
13	2.70	2.75	2.80	2.95	3.35	1.50	1.60	1.90	1.85	2.20	2.75
14	2.70	2.60	2.65	3.05	3.20	1.35	1.50	2.00	1.85	2.10	2.75
15	2.70	2.35	2.55	3.25	3.05	1.10	1.45	2.00	1.85	2.15	2.75
16	2.70	2.35	2.50	3.05	2.90	1.15	1.35	1.90	1.90	2.05	2.65
17	2.75	2.25	2.60	3.05	2.85	1.05	1.45	1.80	1.90	2.25	2.70
18	2.70	2.15	2.60	3.10	2.85	1.00	1.65	1.85	1.80	2.25	2.55
19	2.75	2.25	2.50	3.00	3.00	1.15	1.80	1.90	1.80	2.35	2.50
20	2.75	2.45	2.55	3.05	2.90	1.25	1.85	1.85	1.80	1.90	2.55
21	2.80	2.35	2.70	3.05	2.85	1.50	2.00	1.85	1.80	2.00	2.55
22	2.80	2.40	2.55	3.00	2.80	1.85	1.90	1.90	1.90	1.85	2.50
23	2.80	2.40	2.65	2.90	2.70	2.20	1.80	1.80	2.00	1.95	2.60
24	2.80	2.45	2.55	2.90	2.80	2.45	1.90	1.85	1.90	2.15	2.65
25	2.85	2.35	2.70	2.85	2.95	2.05	1.75	1.90	1.90	2.25	2.75
26	2.90	2.30	2.65	2.80	2.85	1.95	1.60	2.00	1.90	2.30	2.75
27	2.90	2.35	2.55	2.70	2.80	1.85	1.50	2.00	1.90	2.40	2.75
28	2.90	2.30	2.55	2.70	2.80	1.70	1.60	2.05	1.80	2.40	2.70
29	2.90	2.40	2.65	2.55	2.90	2.00	1.55	2.05	1.95	2.40	2.85
30	2.90	.....	2.65	2.55	2.55	1.95	1.50	2.00	1.95	2.40	2.85
31	2.85	.....	.....	2.60	.....	2.15	1.60	.....	2.25	.....	2.85

South Platte River at Deansbury, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.93	2.96	3.30	4.39	2.70	2.78	0.98	1.39	1.80	1.46	1.36	0.80
2	2.95	3.02	3.15	4.24	2.68	2.78	.93	1.35	1.80	1.45	1.20	.78
3	2.97	3.14	3.09	4.12	2.64	2.74	.90	1.32	1.68	1.42	1.20	1.70
4	2.97	3.14	3.45	3.85	3.05	2.54	.88	1.28	1.90	1.45	1.16	a3.48
5	3.00	3.11	3.20	3.86	2.91	2.35	.96	1.18	1.74	1.42	1.07	3.27
6	3.10	3.12	3.23	4.68	3.30	2.24	.90	1.17	1.27	1.40	1.10	3.06
7	3.35	3.12	3.31	5.09	3.15	2.11	.95	1.12	1.30	1.38	.87	2.96
8	3.28	3.17	3.11	5.46	3.25	2.00	.99	1.02	1.25	1.32	.86	2.90
9	3.24	3.15	3.30	5.73	2.85	1.90	1.03	.93	1.23	1.33	1.11	3.00
10	3.40	3.18	3.26	5.36	2.65	1.80	.92	.83	1.55	1.42	1.20	2.90
11	3.12	3.19	3.35	5.35	2.52	1.68	.82	.77	1.83	1.42	1.00	2.81
12	3.05	3.20	3.31	5.53	2.33	1.60	.78	.74	1.74	1.41	.88	2.80
13	3.03	3.17	3.39	5.08	2.30	1.50	.73	.71	1.63	1.42	.97	2.80
14	2.95	3.22	3.33	5.47	2.44	1.45	.70	.73	1.54	1.39	1.22	2.80
15	2.91	3.17	3.16	6.00	2.28	1.44	.76	.74	1.43	1.37	1.19	2.76
16	2.90	3.26	3.38	6.47	2.30	1.40	1.32	.97	1.34	1.31	1.17	2.97
17	2.96	3.22	3.44	6.21	2.31	1.34	1.77	.96	1.30	1.29	1.18	2.90
18	3.00	3.22	3.14	5.72	2.43	1.30	1.72	1.79	1.37	1.26	1.18	2.71
19	3.00	3.26	3.45	5.36	2.41	1.24	1.92	1.73	1.54	1.33	1.15	2.76
20	3.05	3.28	3.67	5.41	2.24	1.24	2.09	1.68	1.71	1.37	1.17	2.81
21	3.05	3.34	3.80	5.39	2.15	1.27	2.21	1.34	1.80	1.27	1.16	2.77
22	3.08	3.33	3.87	5.64	2.12	1.29	2.11	1.42	1.75	1.28	1.07	2.73
23	3.02	3.31	3.97	5.89	2.20	1.25	1.92	1.72	1.66	1.40	1.07	2.72
24	3.01	3.26	4.26	5.97	2.40	1.18	1.62	1.39	1.57	1.37	1.19	2.69
25	2.95	3.34	4.75	6.79	2.43	1.15	2.14	1.31	1.56	1.38	1.10	2.67
26	3.02	3.41	5.81	a3.42	2.40	1.10	2.40	1.19	1.50	1.45	.92	2.69
27	2.94	3.42	6.52	3.59	2.46	1.10	2.35	1.08	1.50	1.43	.78	2.80
28	2.97	3.40	6.15	3.63	2.50	1.03	2.17	1.03	1.51	1.42	.80	2.72
29	3.00	3.23	5.86	3.18	2.49	1.03	1.81	1.07	1.55	1.41	.79	2.73
30	3.00	.....	5.30	3.02	2.58	1.03	1.60	1.17	1.50	1.31	.81	2.77
31	2.97	.....	5.06	.....	2.71	.....	1.54	1.40	.....	1.30	.....	2.76

a January 1 to April 25, station No. 1; April 26 to December 3, station No. 2; December 4 to 31, station No. 1.

South Platte River at Denver, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.45	3.55	4.00	4.45	5.55	5.20	4.65	4.35	5.10	4.90	4.65	4.60
2	3.50	3.50	3.95	4.50	5.35	5.30	4.60	4.30	5.20	5.00	4.70	4.70
3	3.55	4.20	4.15	4.65	5.10	5.05	4.10	4.60	5.15	5.00	4.65	4.70
4	3.50	3.85	4.05	4.55	5.10	5.00	(a)	4.50	4.95	4.60	4.70	4.65
5	3.50	3.70	4.00	4.50	5.20	4.95	(a)	4.30	4.85	4.50	4.65	4.65
6	3.45	3.85	3.95	4.45	5.10	4.90	(a)	4.35	4.85	4.45	4.70	4.65
7	3.40	3.80	3.95	4.60	5.00	4.90	(a)	4.30	4.90	4.55	4.65	4.80
8	3.35	3.75	4.15	4.55	5.05	4.90	4.10	4.25	4.80	4.50	4.70	4.90
9	3.30	3.70	4.25	4.70	4.95	4.75	4.20	4.20	4.85	4.45	4.73	4.90
10	3.60	3.85	4.15	4.55	4.70	4.65	4.25	4.30	5.05	4.35	4.80	4.90
11	3.75	3.35	4.15	4.45	4.75	4.50	4.10	4.25	5.05	4.30	4.75	4.85
12	3.80	3.15	4.15	4.50	4.45	4.55	4.00	4.30	5.10	4.40	4.85	4.80
13	3.85	4.00	4.20	4.65	4.35	4.60	4.00	4.20	5.05	4.45	4.90	4.85
14	3.70	3.90	4.05	4.90	4.65	4.00	4.30	4.25	5.00	5.10	4.85	4.90
15	3.70	3.75	4.15	4.85	4.60	4.40	4.25	4.05	5.05	5.00	4.80	4.80
16	3.65	3.90	4.25	5.05	5.00	4.45	4.45	4.00	5.00	4.85	4.70	4.80
17	3.75	4.00	4.15	5.10	4.60	4.25	4.40	4.30	5.00	4.80	4.65	4.75
18	3.85	4.05	4.00	4.95	4.85	4.05	4.70	4.35	5.05	4.90	4.70	4.80
19	3.60	4.10	4.15	5.00	4.80	4.10	4.00	4.50	5.15	4.95	4.70	4.75
20	3.70	4.05	4.20	4.90	4.75	4.10	4.30	4.50	5.00	5.10	4.75	4.85
21	3.95	3.95	4.10	4.85	4.60	4.10	4.45	(b)	4.95	5.10	4.80	4.80
22	3.80	3.95	4.25	4.95	4.40	4.10	4.50	(b)	5.00	5.15	4.80	4.75
23	3.70	4.00	4.50	5.05	4.40	4.15	4.45	(b)	4.90	5.20	4.80	4.80
24	3.75	4.05	4.55	5.00	4.40	4.20	4.45	(b)	4.80	5.10	4.90	4.80
25	3.75	4.00	4.70	5.10	4.95	4.50	5.50	(b)	5.00	5.05	4.90	4.75
26	3.85	4.10	4.85	5.25	4.85	4.55	5.05	4.80	5.05	5.00	4.90	4.80
27	3.70	4.05	4.75	5.70	4.80	4.50	4.95	4.85	5.10	4.90	(c)	4.70
28	3.75	4.00	4.70	5.65	4.85	4.45	4.80	4.85	5.10	5.00	(c)	4.75
29	3.90	4.05	4.75	5.75	4.95	4.65	4.90	4.80	4.95	4.90	(c)	4.80
30	4.00	.....	4.65	5.60	4.85	4.65	4.85	4.85	5.00	4.70	(c)	4.65
31	3.80	.....	4.55	.....	5.00	.....	4.65	5.00	.....	4.65	.....	4.60

a July 4 to 7 water below gage. *b* September 21 to 25 sand in front of gage. *c* Frozen.

South Platte River at Orchard, Colorado, for 1895–96.

Day.	1895.		1896.				
	Nov.	Dec.	Jan.	Feb. *a*	Mar.	Apr.	Dec.
1	.....	4.15	3.85	4.15	3.70	3.70	4.26
2	.....	4.10	3.85	.....	3.70	3.70	4.25
3	.....	4.10	3.90	.....	3.70	3.75	4.45
4	.....	4.10	3.95	.....	3.75	4.00	4.60
5	.....	4.10	4.00	.....	3.80	.....	4.65
6	.....	4.10	4.00	.....	3.85	.....	4.65
7	.....	4.10	4.05	.....	3.90	.....	4.65
8	.....	4.05	4.10	.....	3.90	.....	4.65
9	.....	4.00	4.10	.....	3.90	.....	4.50
10	.....	4.00	4.00	.....	3.85	.....	4.45
11	.....	4.00	4.00	.....	3.80	.....	4.40
12	.....	4.00	3.95	.....	3.75	.....	4.60
13	.....	3.95	3.90	.....	3.70	.....	4.60
14	.....	3.95	3.80	.....	3.70	.....	4.80
15	.....	3.95	3.90	.....	3.70	.....	5.00
16	.....	3.95	3.95	3.90	3.70	.....	5.20
17	.....	3.95	4.00	3.85	3.70	.....	4.80
18	.....	3.90	4.00	3.85	3.75	.....	4.30
19	.....	3.90	4.00	3.85	3.75	.....	4.00
20	.....	3.90	4.00	3.85	3.80	.....	3.85
21	.....	3.95	4.00	3.85	3.80	.....	3.80
22	4.00	3.95	4.00	3.85	3.80	.....	3.80
23	4.05	3.95	4.00	3.80	3.75	.....	3.80
24	4.05	3.90	4.00	3.80	3.70	.....	3.80
25	4.10	3.90	4.00	3.75	3.70	.....	3.80
26	4.10	3.90	4.00	3.75	3.75	.....	3.80
27	4.10	3.85	4.00	3.70	3.75	.....	3.75
28	4.10	3.80	4.00	3.70	3.80	.....	3.75
29	4.15	3.80	4.00	3.70	3.85	.....	3.75
30	4.15	3.85	4.10	.....	3.80	.....	3.75
31	.....	3.85	4.10	.....	3.70	.....	3.75

a February 2 to 15 observer away; no record.

Bear Creek at Morrison, Colorado.

Day.	Apr.	May.	June.	July.a	Aug.a	Sept.	Oct.
1	.....	0.92	1.00	0.70	.....	2.88	2.80
2	.....	.87	.95	.69	.....	2.83	2.75
3	.....	.97	.90	.78	.....	2.90	2.75
4	.....	1.02	.85	.70	.....	2.90	2.75
5	.....	.97	.83	.75	2.93	2.85	2.75
6	0.70	1.10	.85	.70	3.00	2.80	2.75
7	.80	1.07	.85	.78	3.00	2.83	2.75
8	.80	1.02	.80	.78	3.00	2.79	2.75
9	.68	.87	.78	.78	2.88	2.83	2.73
10	.75	.90	.75	.68	2.88	3.00	2.73
11	.73	.92	.75	.63	2.85	2.95	2.70
12	.77	.87	.71	.60	2.83	2.90	2.70
13	.80	.82	.72	.55	2.80	2.85	2.70
14	.92	.80	.71	.55	2.78	2.78	2.70
15	1.00	.85	.73	.58	2.75	2.75	2.70
16	.90	.82	.75	.80	2.75	2.75	2.70
17	.95	.92	.74	.95	2.78	2.75	2.70
18	.72	.92	.75	1.00	2.80	2.80	2.70
19	.75	.90	.75	1.03	2.83	2.98	2.70
20	.80	.87	.73	1.03	2.85	2.98	2.70
21	.97	.87	.73	.93	2.90	2.88	2.70
22	1.02	.92	.73	.90	2.98	2.88	2.70
23	1.07	.95	.70	1.03	2.98	2.83	2.70
24	1.10	1.07	.70	.88	2.88	2.80	2.78
25	1.15	1.05	.78	.....	2.80	2.80	2.78
26	1.17	1.02	.95	.....	2.80	2.80	2.75
27	1.22	.92	.80	.....	2.80	2.90	2.75
28	1.17	.95	.80	.....	2.78	2.85	2.78
29	1.11	.97	.75	.....	2.75	2.80	2.70
30	.95	1.02	.73	.....	2.88	2.80	2.70
31	.....	1.00	.....	.....	2.98	.....	2.65

a From July 25 to August 5 no record; rod washed away by flood.

South Boulder Creek at Marshall, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.80	1.85	2.30	1.55	1 15	1.10	0.95
2	1.05	1.55	2.10	1.55	1.05	1.10	.95
3	.90	1.65	2.10	1.55	1.05	1.10	.85
4	.95	1.85	2.30	1.50	1.05	1.10	.80
5	.90	1.70	2.15	1.50	1.05	1.10	.80
6	.90	1.90	2.20	1.45	1.05	1.10	.80
7	1.05	1.95	2.00	1.45	1.05	1.05	.85
8	1.05	2.05	1.95	1.45	1.05	1.05	1.00
9	1.05	2.10	2.20	1.40	.96	1.05	1.00
10	1.05	2.10	2.15	1.40	.95	1.10	1.00
11	1.15	2.20	2.25	1.40	.95	1.10	1.00
12	1.15	1.95	2.15	1.35	.95	1.10	1.00
13	1.20	1.80	2.10	1.35	.95	1.10	.95
14	1.35	1.75	2.05	1.35	.95	1.10	.95
15	1.35	1.70	2.05	1.30	.95	1.05	.90
16	1.35	1.75	2.00	1.60	.95	1.05	.90
17	1.45	1.75	1.95	1.50	.95	1.10	.90
18	1.15	1.70	1.95	1.50	1.00	1.15	.90
19	1.20	1.65	1.95	1.50	1.40	1.15	.90
20	1.20	1.70	1.90	1.40	1.90	1.05	.85
21	1.40	1.65	1.90	1.30	1.45	1.05	.80
22	1.55	1.70	1.85	1.30	1.20	1.00	.80
23	1.60	1.85	1.85	1.30	1.30	1.00	.90
24	1.75	2.00	1.80	1.30	1.15	1.00	.90
25	1.70	2.00	1.75	1.30	1.10	1.00	.90
26	1.80	2.30	1.70	1.30	1.10	1.00	.90
27	1.90	2.35	1.65	1.30	1.10	1.00	.90
28	1.90	2.40	1.65	1.30	1.10	1.00	.80
29	1.80	2.45	1.65	1.25	1.10	1.00	.80
30	1.80	2.55	1.60	1.25	1.10	1.00	.80
31	.....	2.50	.....	1.20	1.10	.....	.80

Boulder Creek at Boulder, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.20	1.10	2.05	1.30	0.98	1.08	0.65
2	.35	1.10	1.77	1.30	.95	1.00	.63
3	.22	1.15	1.90	1.30	.88	1.08	.60
4	.27	1.17	1.92	1.30	.83	1.03	.55
5	.25	1.25	1.97	1.35	.80	1.00	.50
6	.27	1.35	1.97	1.73	.80	.98	.50
7	.27	1.45	1.90	1.57	.78	.93	.45
8	.30	1.85	1.88	1.45	.73	.88	.43
9	.45	1.85	1.95	1.38	.69	.85	.45
10	.47	1.75	1.95	1.35	.65	.90	.45
11	.50	1.75	2.00	1.28	.65	.90	.53
12	.50	1.40	1.88	1.23	.65	.80	.60
13	.52	1.30	1.80	1.15	.63	.73	.58
14	.57	1.17	1.83	1.18	.60	.70	.55
15	.57	1.12	1.88	1.32	.60	.65	.50
16	.77	1.07	1.80	1.50	.65	.60	.50
17	.77	.95	1.75	1.45	.70	.63	.45
18	.77	1.07	1.65	1.38	1.23	.75	.45
19	.62	1.02	1.60	1.35	2.15	.90	.45
20	.75	1.00	1.55	1.25	1.05	.80	.43
21	.82	1.12	1.55	1.23	1.20	.80	.40
22	1.00	1.15	1.55	1.30	1.35	.75	.40
23	1.07	1.45	1.48	1.35	1.28	.78	.45
24	1.20	1.70	1.45	1.45	1.15	.80	.45
25	1.27	1.90	1.48	1.45	.98	.75	.40
26	1.45	1.95	1.43	1.40	.88	.80	.45
27	1.80	2.05	1.40	1.38	.88	.80	.45
28	1.85	2.15	1.38	1.33	.90	.75	.45
29	1.75	2.20	1.33	1.30	1.00	.70	.40
30	1.60	2.32	1.33	1.18	1.10	.70	.40
31	.....	2.15	.....	1.05	1.20	.....	.35

St. Vrain Creek at Lyons, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.63	2.60	3.50	2.80	2.50	2.75	2.38
2	1.77	2.65	3.45	2.85	2.50	2.63	2.33
3	1.85	2.45	3.50	2.85	2.50	2.75	2.38
4	1.90	2.55	3.65	2.80	2.50	2.55	2.38
5	1.85	2.55	3.35	2.80	2.48	2.58	2.38
6	2.00	2.80	3.60	2.80	2.48	2.55	2.30
7	2.05	2.95	3.30	2.80	2.48	2.55	2.30
8	2.20	3.15	3.30	2.80	2.40	2.30	2.28
9	2.10	3.20	3.70	2.70	2.38	2.35	2.30
10	2.10	3.10	3.70	2.70	2.30	2.45	2.28
11	2.15	3.10	3.70	2.75	2.30	2.85	2.30
12	2.20	2.80	3.40	2.65	2.28	2.80	2.25
13	2.10	2.65	3.35	2.65	2.23	2.55	2.25
14	2.15	2.50	3.35	2.65	2.20	2.45	2.28
15	2.30	2.50	3.35	2.85	2.20	2.43	2.30
16	2.30	2.50	3.85	3.10	2.25	2.35	2.28
17	2.15	2.50	3.30	3.05	2.38	2.38	2.25
18	2.10	2.50	3.30	2.95	3.40	2.45	2.25
19	2.00	2.60	3.10	2.80	3.10	2.58	2.23
20	2.35	2.50	3.20	2.75	2.70	2.50	2.23
21	2.55	2.50	3.15	2.65	2.80	2.53	2.28
22	2.55	2.55	3.15	2.70	3.50	2.45	1.93
23	2.60	2.85	3.10	2.95	3.35	3.50	1.75
24	2.55	3.10	2.95	3.30	2.95	2.58	1.85
25	2.60	3.40	3.25	3.15	2.75	2.45	1.75
26	2.70	3.40	2.85	3.05	2.70	2.43	1.63
27	2.95	3.35	2.80	2.85	2.60	2.40	2.20
28	2.90	3.55	2.80	2.70	2.55	2.43	2.23
29	2.45	3.85	2.85	2.60	2.50	2.38	2.20
30	2.65	4.40	2.75	2.60	2.65	2.38	2.28
31	.....	3.85	.....	2.53	2.75	.....	2.20

Big Thompson Creek at Arkins, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	0.10	1.35	1.20	1.20	1.25	1.05
2	.....	.50	1.65	1.25	1.10	1.00	.95
3	.....	.80	1.80	1.25	1.05	1.00	.95
4	.....	.85	1.80	1.20	1.00	1.00	.90
5	.....	.90	1.65	1.20	.95	1.00	.90
6	.....	1.00	1.70	1.20	.90	.85	.85
7	.....	1.10	1.50	1.15	.75	.80	.90
8	.....	1.05	1.55	1.55	.75	1.00	.80
9	.....	1.20	1.45	1.20	.75	.95	.90
10	.....	1.25	1.55	1.15	.70	.90	.85
11	.....	1.35	1.65	1.25	.75	1.00	.90
12	.....	1.15	1.45	1.20	.75	.95	.85
13	.....	1.10	1.55	1.10	.75	.85	.85
14	.....	.95	1.65	1.15	.75	.90	.85
15	.....	.90	1.55	1.20	.65	.90	.90
16	.....	.85	1.55	1.70	.80	.80	.85
17	.....	.85	1.55	1.55	.70	1.00	.80
18	.....	.85	1.55	1.25	.75	.95	.75
19	.....	.90	1.30	1.45	.85	.95	.70
20	.....	.95	1.35	1.35	.95	1.00	.65
21	.....	1.00	1.40	1.30	1.50	1.05	.60
22	.....	1.10	1.35	1.20	1.75	1.00	.60
23	.....	1.30	1.40	1.35	1.65	1.00	.65
24	.....	1.70	1.30	1.70	1.55	1.05	.65
25	.....	1.75	1.25	1.45	1.45	1.00	.60
26	.....	1.75	1.25	1.45	1.35	1.05	.40
27	.....	1.75	1.20	1.45	1.25	1.00	.40
28	0.80	1.65	1.20	1.40	1.15	1.05	.40
29	.60	1.80	1.25	1.40	1.00	1.00	.40
30	.25	2.30	1.20	1.30	1.10	1.00	.40
31	.....	1.80	.....	1.25	1.30	.....	.40

Frenchman River at Palisade, Nebraska.

[River heights on main and supplementary gages. Gage heights are all referred to original zero of main gage.]

Date.	South gage.	Main gage.	North gage.	Differences in heights.		
				South gage, main gage.	Main gage, north gage.	South gage, north gage.
1896.						
June 18	1.85	1.66	1.11	0.19	0.55	0.74
June 23	2.11	2.05	1.35	.06	.70	.76
June 25	2.10	1.93	1.35	.17	.58	.75
June 27	2.06	1.87	1.34	.19	.53	.72
July 1	2.14	1.96	1.40	.18	.56	.74
July 3	2.13	1.94	1.39	.19	.55	.74
July 5	2.13	1.93	1.38	.20	.55	.74
July 7	2.03	1.87	1.27	.16	.60	.76
July 9	1.97	1.75	1.15	.22	.60	.82
July 11	1.94	1.73	1.17	.21	.56	.77
July 14	1.96	1.74	1.19	.22	.55	.77
July 16	1.99	2.05	1.21	—.06	.84	.78
July 18	1.91	1.75	1.13	+.16	.62	.78
July 21	1.89	1.74	1.11	.15	.63	.78
July 23	1.89	1.74	1.13	.15	.61	.76
July 25	1.87	1.75	1.12	.12	.63	.75
July 28	1.89	1.75	1.13	.14	.62	.76
July 30	1.89	1.74	1.15	.15	.59	.74
Aug. 1	1.89	1.72	1.14	.17	.58	.75
Aug. 4	1.89	1.70	1.13	.19	.57	.76
Aug. 6	1.89	1.69	1.13	.20	.56	.76
Aug. 8	1.88	1.69	1.12	.19	.57	.76
Aug. 25	1.87	1.79	1.08	.08	.71	.79
Aug. 28	1.87	1.74	1.06	.13	.68	.81
Aug. 31	1.87	1.75	1.09	.12	.66	.78
Sept. 4	1.83	1.79	1.17	.04	.62	.66
Sept. 9	1.89	1.74	1.13	.15	.61	.76
Sept. 12	1.84	1.75	1.10	.09	.65	.74
Sept. 14	1.99	1.79	1.17	.20	.62	.82
Sept. 20	1.98	1.77	1 19	.21	.58	.79
Sept. 29	2.00	1.79	1.23	.21	.56	.77

Republican River at Junction City, Kansas.

Day.	Jan.	Feb.	Mar.a	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.55	3.65	*3.50*	3.50	4.45	4.90	3.55	4.00	3.10	2.80	4.65	3.70
2	3.40	3.95	*3.50*	3.50	4.30	6.30	3.35	3.80	3.00	2.80	4.25	3.85
3	3.30	4.05	*3.50*	3.50	4.25	7.20	3.30	3.60	2.95	2.80	3.90	3.80
4	3.05	3.90	*3.50*	3.50	5.25	6.20	3.40	3.45	2.85	2.75	3.55	3.75
5	3.10	3.80	*3.50*	3.50	5.95	6.20	3.35	3.60	2.80	2.80	3.40	3.95
6	3.05	3.85	*3.50*	3.50	6.20	4.95	6.10	3.60	2.80	2.75	3.30	3.80
7	2.90	4.05	*3.50*	3.50	6.45	4.95	5.80	3.45	2.70	2.70	3.20	3.60
8	3.10	4.00	*3.50*	3.50	6.45	4.55	5.70	3.35	2.65	2.70	3.10	3.50
9	3.05	3.80	*3.50*	3.65	5.10	4.65	5.40	3.25	2.60	2.70	3.10	3.50
10	3.35	3.75	*3.50*	3.45	4.50	4.55	5.00	3.15	2.75	2.70	3.10	3.50
11	3.30	3.85	*3.50*	3.40	4.20	4.30	4.85	3.00	2.75	2.70	3.20	3.50
12	3.30	3.80	*3.50*	3.50	4.10	4.15	4.95	3.55	2.60	2.70	3.20	3.50
13	3.35	3.75	*3.50*	3.45	4.40	3.95	4.85	3.70	2.60	2.75	3.20	3.50
14	3.30	3.70	*3.50*	3.50	5.40	3.85	4.55	3.65	5.00	2.80	3.20	3.55
15	3.35	3.65	*3.50*	4.90	5.70	3.85	4.40	3.20	3.65	2.80	3.20	3.60
16	3.50	3.60	*3.50*	6.50	5.90	3.85	4.20	3.00	3.50	2.80	3.30	3.60
17	3.30	3.60	*3.50*	6.75	5.60	3.75	4.20	3.00	3.70	2.70	3.30	3.65
18	3.20	3.60	*3.50*	5.65	5.00	3.60	10.97	3.00	3.75	2.70	3.30	3.50
19	3.10	3.55	*3.50*	5.10	6.50	3.55	8.80	3.20	4.70	2.75	3.35	3.30
20	3.05	3.55	*3.50*	4.55	7.00	3.45	6.50	4.50	5.40	2.70	3.35	3.45
21	3.05	3.55	*3.50*	4.25	6.10	3.70	5.15	4.95	4.35	2.70	3.30	3.50
22	3.20	3.60	*3.50*	4.10	5.30	3.55	5.65	5.35	3.65	2.70	3.25	3.60
23	3.40	3.60	*3.50*	4.10	4.75	3.55	5.10	4.70	3.35	2.70	3.05	3.80
24	3.30	3.55	*3.50*	6.20	4.40	3.85	4.35	4.35	3.15	2.70	3.10	3.70
25	3.20	3.55	*3.50*	5.90	4.25	4.05	4.10	4.05	3.05	2.70	3.00	3.50
26	3.15	3.50	*3.50*	5.30	4.05	3.65	3.80	3.80	3.00	2.70	3.50	3.50
27	3.05	3.55	*3.50*	5.40	3.85	4.15	3.65	3.75	2.90	2.75	3.50	3.50
28	3.20	3.50	*3.50*	4.95	3.80	3.90	3.60	3.95	2.80	2.50	3.40	3.50
29	3.30	3.50	*3.50*	4.75	3.75	3.85	3.55	3.55	2.80	3.00	3.30	3.70
30	3.40	.....	*3.50*	4.85	4.05	3.45	3.45	3.35	2.80	4.65	3.50	3.65
31	3.40	.....	*3.50*	.....	6.40	.....	3.45	3.25	.....	5.25	.....	3.75

a Figures in italics are estimated.

Solomon River at Beloit, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	2.90	2.00	2.70	4.05	7.13	4.55	4.95	3.75	3.20	3.30	3.10
2	2.70	2.82	3.00	2.35	4.20	9.50	4.25	4.75	3.80	3.60	2.90	3.00
3	2.30	2.92	2.75	2.35	3.80	7.20	4.50	4.45	3.50	3.20	2.70	3.10
4	2.70	2.92	2.80	2.40	3.65	5.90	4.43	4.05	3.40	2.40	2.90	3.10
5	1.75	2.92	2.25	2.80	3.65	4.85	4.80	3.95	3.40	3.10	2.85	3.10
6	2.70	2.90	2.70	2.75	3.55	4.75	6.80	3.85	2.55	2.60	2.80	2.30
7	2.30	2.92	2.70	2.80	3.50	4.90	6.00	4.10	3.25	3.00	3.00	3.10
8	2.70	2.95	2.25	2.75	3.30	5.55	4.50	4.60	3.40	2.95	2.20	3.10
9	2.70	2.42	2.90	2.60	3.20	4.65	4.25	4.25	2.85	3.15	3.00	3.10
10	2.70	2.92	2.70	2.60	3.20	4.25	4.15	4.20	3.40	3.05	3.00	3.10
11	2.30	3.00	2.80	2.00	3.40	4.15	5.20	4.00	3.45	2.15	3.05	3.10
12	1.90	2.92	2.75	4.85	3.25	4.10	4.70	4.15	3.40	2.80	3.00	3.30
13	2.70	2.55	2.75	15.50	3.30	4.05	4.25	4.00	2.85	2.65	3.00	2.65
14	2.30	2.95	2.75	11.60	4.60	3.80	4.00	3.70	3.75	2.60	3.00	3.30
15	2.30	2.92	2.25	11.90	4.80	3.85	3.85	3.60	5.25	2.60	2.20	3.25
16	2.70	2.37	2.65	5.80	4.70	3.60	3.65	3.65	4.05	2.85	3.05	3.35
17	2.70	2.82	2.75	4.50	8.32	3.80	3.85	3.45	3.75	3.15	3.00	3.05
18	2.95	2.72	2.70	4.35	4.40	3.80	4.05	3.70	3.95	2.50	3.00	3.15
19	2.30	2.75	2.70	4.20	4.30	4.20	3.95	3.65	4.00	2.75	3.05	3.10
20	2.90	2.75	2.75	4.60	5.40	4.60	3.95	3.90	4.15	3.05	3.10	2.50
21	2.95	2.72	2.75	4.20	4.80	4.15	3.90	4.55	3.95	2.65	2.70	3.15
22	2.95	2.70	2.50	3.90	4.25	4.00	4.60	4.35	3.70	3.05	2.40	3.15
23	2.70	2.25	2.70	3.70	4.00	4.05	4.05	4.40	3.60	3.05	3.10	3.20
24	2.95	2.70	2.70	3.70	3.80	3.75	4.05	4.55	3.85	2.80	3.10	3.20
25	2.95	2.70	2.70	3.65	4.35	3.90	3.95	4.95	3.55	2.55	3.10	2.60
26	2.30	2.75	2.75	3.50	4.15	3.95	4.00	4.40	3.80	2.55	2.30	3.15
27	2.90	2.70	3.00	3.65	3.65	4.05	4.00	4.25	2.65	2.55	3.10	2.50
28	2.90	2.60	2.80	4.05	3.70	4.05	3.90	4.15	3.55	3.10	2.90	3.20
29	2.90	2.75	2.30	3.75	3.35	4.10	5.30	3.90	3.10	8.50	2.30	3.20
30	2.90	.....	2.75	3.75	3.30	5.90	16.75	3.65	2.75	5.10	3.05	3.20
31	2.87	.....	2.60	.....	3.70	.....	6.25	3.90	.....	3.75	.....	3.20

Saline River at Beverly, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.20	4.45	4.35	4.15	5.20	20.25	7.00	5.10	4.40	4.20	5.65	4.20
2	4.20	4.50	4.20	4.30	5.35	23.00	6.40	4.80	4.50	4.35	5.25	4.30
3	4.00	4.45	4.15	4.35	5.10	23.50	6.95	4.70	4.45	4.40	4.90	4.40
4	3.85	4.80	4.10	4.20	10.55	21.50	7.15	4.80	4.20	4.20	4.90	4.35
5	3.85	4.70	4.25	4.15	8.85	13.05	6.95	4.60	4.30	4.20	4.75	4.30
6	4.40	4.45	4.25	4.20	5.20	9.20	6.13	5.00	4.15	4.30	4.75	4.30
7	4.30	4.35	4.30	4.15	4.85	12.10	5.75	5.00	4.35	4.35	4.75	4.15
8	4.40	4.35	4.30	4.60	4.70	10.55	7.35	5.05	4.30	4.35	4.65	4.80
9	4.15	4.25	4.45	4.90	4.75	8.50	6.00	4.65	4.10	4.35	4.45	4.65
10	4.25	4.15	4.25	4.65	4.65	6.90	5.75	4.60	4.45	4.35	4.70	4.55
11	4.30	4.25	4.50	4.50	4.65	6.50	8.10	4.85	4.50	4.15	4.65	4.65
12	4.55	4.25	4.35	4.45	4.70	6.20	9.35	4.55	4.30	4.35	4.45	4.50
13	4.50	4.35	4.30	6.40	7.30	6.05	6.90	4.65	4.40	4.30	4.30	4.40
14	4.50	4.35	4.40	9.70	7.40	5.90	5.85	4.45	4.40	4.35	4.55	4.05
15	4.40	4.30	4.40	5.80	5.60	5.70	5.55	4.20	4.40	4.35	4.30	4.70
16	4.30	4.10	4.45	5.05	7.25	5.60	5.45	4.75	4.50	4.35	4.50	4.50
17	4.50	4.15	4.25	5.50	6.50	5.80	5.30	4.95	4.55	4.30	4.60	4.55
18	4.45	4.20	4.40	5.40	5.80	5.75	8.50	4.85	4.45	4.20	4.50	4.25
19	4.50	4.15	4.25	5.05	5.75	5.50	7.65	4.70	4.60	4.25	4.60	4.50
20	4.40	4.40	4.35	4.80	7.20	5.50	7.25	4.80	4.70	4.10	4.40	4.25
21	4.55	4.25	4.30	4.90	6.55	10.80	5.95	4.75	4.75	4.25	4.40	4.35
22	4.55	4.25	4.20	4.75	5.75	7.65	5.45	4.75	4.60	4.35	4.55	4.30
23	4.60	4.35	4.35	4.70	5.20	8.85	5.25	7.50	4.50	4.35	4.20	4.25
24	4.55	4.20	4.20	4.65	4.95	6.80	5.85	5.95	4.50	4.25	4.30	4.60
25	4.40	4.15	4.30	4.65	4.70	6.20	5.55	5.10	4.40	4.05	4.55	4.50
26	4.25	4.20	4.40	6.60	4.60	6.75	5.10	4.85	4.35	4.30	4.55	4.15
27	4.25	4.30	4.30	9.30	4.55	8.30	5.00	4.65	4.35	4.15	4.30	.....
28	4.20	4.40	4.25	7.35	4.45	8.20	4.95	4.70	4.40	4.40	4.35	.....
29	4.15	4.25	4.40	5.75	4.40	8.00	4.90	4.55	4.30	5.75	4.30	.....
30	4.20	.....	4.25	5.30	4.25	7.90	6.90	4.50	4.45	15.35	4.25	.....
31	4.40	.....	4.10	.....	13.00	.....	5.85	4.45	.....	7.10	.....	.....

Smoky Hill River at Ellsworth, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.50	1.40	1.30	1.20	1.72	1.85	2.63	2.05	1.68	1.45	1.95	1.33
2	1.50	1.50	1.27	1.20	1.67	1.75	2.45	1.90	1.60	1.43	1.85	1.30
3	1.42	1.50	1.35	1.20	1.65	1.62	2.25	1.78	1.58	1.40	1.88	1.30
4	1.42	1.50	1.27	1.20	1.70	1.55	2.20	1.68	1.53	1.40	1.78	1.30
5	1.35	1.50	1.30	1.20	1.62	1.90	2.13	1.65	1.48	1.43	1.70	1.28
6	1.32	1.50	1.30	1.20	1.60	1.95	2.03	1.78	1.45	1.35	1.63	1.28
7	1.27	1.40	1.30	1.20	1.52	4.05	4.30	1.88	1.43	1.35	1.53	1.30
8	1.42	1.30	1.30	2.10	1.50	7.10	2.10	1.75	1.40	1.30	1.50	1.25
9	1.42	1.35	1.30	1.42	1.47	3.75	2.00	1.65	1.40	1.30	1.50	1.23
10	1.35	1.47	1.30	1.27	1.50	2.75	1.93	1.58	1.50	1.40	1.45	1.25
11	1.35	1.40	1.27	1.20	1.45	2.45	3.50	1.50	1.48	1.35	1.43	1.25
12	1.32	1.40	1.27	1.55	1.47	2.15	2.90	1.55	1.40	1.33	1.40	1.25
13	1.42	1.40	1.22	2.30	1.85	2.05	2.50	1.58	1.45	1.30	1.40	1.25
14	1.35	1.40	1.37	2.25	1.72	1.95	2.23	1.63	1.43	1.28	1.35	1.20
15	1.32	1.40	1.37	1.85	1.67	1.85	2.03	1.68	1.40	1.25	1.35	1.20
16	1.32	1.40	1.27	1.97	1.62	1.83	2.00	1.60	1.40	1.23	1.35	1.20
17	1.27	1.35	1.32	2.37	1.55	1.80	1.98	1.50	1.40	1.20	1.30	1.23
18	1.27	1.35	1.32	3.00	1.50	1.83	2.90	1.50	1.45	1.20	1.30	1.13
19	1.30	1.35	1.25	2.10	1.50	1.85	3.60	1.55	1.90	1.20	1.20	1.35
20	1.35	1.32	1.30	1.97	1.50	1.73	2.65	1.50	1.68	1.20	1.20	1.25
21	1.32	1.32	1.30	1.97	1.50	4.30	2.35	1.50	1.60	1.20	1.28	1.20
22	1.35	1.35	1.30	1.90	1.47	2.30	2.08	3.00	1.63	1.20	1.15	1.20
23	1.32	1.35	1.30	1.92	1.60	2.10	2.15	2.40	1.68	1.28	1.23	1.20
24	1.40	1.30	1.30	1.87	1.47	2.65	2.15	1.85	1.70	1.28	1.25	1.20
25	1.45	1.30	1.27	4.30	1.40	2.50	2.00	1.95	1.70	1.25	1.25	1.20
26	1.37	1.30	1.30	2.80	1.40	2.35	1.93	2.43	1.68	1.28	1.33	1.25
27	1.52	1.30	1.30	2.10	1.35	2.45	1.88	2.28	1.58	1.30	1.35	1.25
28	1.42	1.30	1.27	2.00	1.30	3.35	2.00	2.05	1.53	1.30	1.30	1.20
29	1.40	1.30	1.20	1.85	1.30	3.30	1.93	1.93	1.50	2.63	1.25	1.20
30	1.40	.....	1.20	1.80	1.30	2.90	2.40	1.83	1.48	2.40	1.30	1.20
31	1.40	.....	1.20	.....	1.52	.....	2.20	1.73	.....	2.28	.....	1.20

Blue River at Manhattan, Kansas.

Day.	Jan.	Feb.	Apr.a	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	3.80	.....	5.60	20.55	11.15	9.75	4.80	4.70	10.50	5.00
2	3.60	3.80	.....	5.35	20.30	18.30	8.80	4.60	4.60	8.50	5.00
3	3.55	3.75	.....	5.75	13.85	22.25	7.10	4.85	4.55	7.90	4.80
4	3.70	3.75	.....	13.95	11.85	22.20	6.70	5.50	4.70	7.00	4.65
5	3.70	3.75	.....	16.75	8.80	19.00	6.00	5.20	4.85	6.40	4.00
6	3.80	3.80	.....	13.25	8.75	10.75	5.70	5.15	5.05	5.90	4.00
7	3.75	3.70	.....	9.50	8.25	8.15	7.60	4.95	4.90	5.40	4.25
8	3.75	3.85	.....	7.60	8.35	7.50	8.25	4.85	4.50	5.00	4.55
9	3.80	3.75	.....	6.20	14.50	7.75	7.35	5.05	4.25	5.00	4.60
10	3.85	3.75	.....	6.45	14.50	9.40	7.35	5.15	4.00	4.90	4.80
11	3.80	3.65	.....	6.10	12.30	9.25	5.85	5.00	4.30	4.80	4.90
12	3.70	3.65	.....	5.75	9.55	9.20	5.45	5.20	4.00	4.50	5.00
13	3.65	3.70	.....	5.65	7.20	9.35	5.60	5.15	3.90	4.40	5.00
14	3.50	3.55	.....	11.20	7.20	8.65	8.10	7.50	3.70	4.30	5.00
15	3.55	3.55	.....	13.65	6.35	7.75	10.75	9.75	3.60	4.20	4.80
16	3.60	3.60	5.50	12.30	5.95	6.40	9.70	8.15	3.70	4.00	4.80
17	3.65	3.65	7.20	11.50	5.60	6.25	7.80	6.65	3.80	4.00	4.70
18	3.60	3.65	9.95	11.00	5.20	9.15	6.95	6.15	3.20	3.80	4.70
19	3.55	3.60	11.05	11.45	5.00	13.90	10.15	10.50	3.15	3.80	4.70
20	3.50	3.70	10.20	14.40	4.90	12.70	15.85	10.25	3.00	3.50	4.50
21	3.75	3.65	8.35	13.25	4.30	12.00	10.25	7.60	3.00	3.50	4.30
22	3.60	3.40	7.20	11.35	4.05	10.75	7.75	6.15	3.00	3.50	4.00
23	3.60	3.45	6.55	10.35	5.10	9.35	5.95	5.85	3.00	3.80	4.00
24	3.30	3.55	6.05	11.05	5.75	7.25	6.75	6.10	3.05	3.80	3.80
25	3.45	3.65	5.70	10.05	5.45	5.60	8.40	5.40	3.00	3.90	3.70
26	3.65	3.60	5.35	9.00	9.20	5.20	6.90	5.05	3.10	4.85	3.50
27	3.75	3.60	5.35	8.35	12.60	5.40	5.75	5.00	3.00	5.60	3.00
28	3.80	3.45	5.20	7.65	10.70	5.10	5.45	4.95	2.80	5.40	3.00
29	3.75	.....	5.20	6.90	9.40	4.65	5.45	4.80	10.00	5.30	3.00
30	3.70	.....	5.25	6.40	8.25	6.70	5.10	4.70	12.75	5.20	3.65
31	3.80	.....	.....	14.15	.....	11.60	4.95	.....	12.25	.....	4.00

a Observations discontinued from March 1 to April 15; observer moved away.

Kansas River at Lecompton, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.82	0.72	0.58	0.73	2.37	8.50	3.25	3.08	2.21	1.25	4.46
2	.76	.70	.73	.71	2.37	9.33	3.50	3.65	2.04	1.21	3.88
3	.85	.72	.75	.67	2.35	8.67	5.96	3.21	1.88	1.17	3.50
4	.65	.77	.60	.67	2.42	7.50	8.00	2.85	1.58	1.21	3.15
5	.42	.85	.83	.65	4.92	6.17	8.25	2.92	1.46	1.08	3.13
6	.49	.98	.79	.67	6.54	7.13	7.58	2.92	1.25	1.15	2.92
7	.57	.93	.67	.79	5.42	6.92	5.13	2.50	1.17	1.04	2.38
8	.56	.88	.38	.77	4.33	6.42	3.88	2.85	1.17	.98	.....
9	.63	.95	.42	.83	3.83	5.92	3.58	2.94	1.17	.92	.....
10	.65	.92	.42	.75	3.60	6.67	3.42	2.71	1.13	.95	.....
11	.77	.88	.46	.75	3.04	6.79	3.54	2.25	1.08	.97	.....
12	.88	.79	.48	1.08	2.58	5.58	3.67	2.17	1.19	1.00	.....
13	.87	.75	.48	1.25	2.42	4.92	3.75	2.08	1.48	1.03	.....
14	.94	.74	.50	1.02	3.08	4.21	3.38	1.96	1.38	1.00	.....
15	.85	.82	.58	.94	3.88	3.54	2.96	1.92	2.92	.95	.....
16	.66	.75	.50	.92	8.46	3.08	2.63	3.04	4.71	.90	.....
17	.60	.72	.42	.92	8.13	2.79	2.40	3.21	3.96	.92	.....
18	.54	.73	.65	1.50	6.58	2.58	3.46	4.46	2.67	.86	.....
19	.53	.69	.75	4.71	5.63	2.38	10.25	4.25	2.25	.85	.....
20	.58	.70	.50	5.00	8.67	2.21	11.63	7.13	2.08	.83	.....
21	.53	.67	.50	4.67	8.92	2.17	9.96	6.63	3.83	.83	.....
22	.51	.66	.52	3.83	8.13	2.13	7.42	4.50	3.08	.81	.....
23	.54	.64	.52	3.29	6.13	2.25	5.58	3.79	2.46	.77	.....
24	.55	.63	.54	2.83	5.67	2.29	4.88	4.44	2.33	.75	.....
25	.18	.58	.58	3.33	5.29	2.67	4.00	3.75	2.08	.75	.....
26	.34	.58	.58	4.04	5.13	3.21	3.46	3.33	1.81	.74	.....
27	.87	.62	.65	4.79	4.42	3.54	3.08	3.04	1.63	.75	.....
28	.60	.60	.73	3.92	3.83	4.48	2.75	2.58	1.52	.75	.....
29	.53	.58	.88	2.96	3.38	4.46	2.50	2.42	1.47	1.00	.....
30	.98	.....	.83	2.60	2.98	3.88	2.42	2.33	1.38	1.29	.....
31	.87	.....	.75	.....	3.71	.....	2.29	2.29	.....	3.81	.....

Kansas River at Lawrence, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.10	0.50	0.50	0.45	1.50	5.20	2.10	1.70	1.40	0.80	3.00	1.00
2	.00	.50	.45	.35	1.45	6.30	2.10	2.55	1.25	.80	2.70	1.00
3	—.25	.45	.45	.35	1.55	5.80	3.60	2.25	1.10	.80	2.30	.80
4	—.75	.45	.40	.35	1.45	5.20	5.20	1.90	1.00	.80	2.30	.90
5	.00	.40	.45	.40	2.70	4.20	5.60	1.90	1.00	.70	2.10	1.00
6	.00	.45	.40	.45	4.30	4.40	5.10	1.90	1.00	.75	1.80	1.20
7	+.10	.55	.40	.45	3.80	4.70	3.90	1.70	1.00	.65	1.60	1.20
8	.05	.55	.40	.50	2.90	4.30	2.55	1.90	.80	.60	1.40	1.20
9	.17	.60	.40	.55	2.55	4.10	2.45	2.15	.80	.60	1.20	1.05
10	.17	.65	.40	.50	2.30	4.25	2.20	1.90	.80	.60	1.10	1.00
11	.15	.50	.40	.45	1.90	4.70	2.25	1.50	.80	.80	1.00	1.00
12	.30	.50	.35	.65	1.75	3.85	2.40	1.35	.80	.80	1.00	1.00
13	.25	.50	.25	.70	1.60	3.30	2.40	1.30	1.20	.80	1.00	1.00
14	.25	.50	.05	.60	1.80	2.90	2.25	1.25	1.40	.70	1.00	1.00
15	.30	.50	.35	.60	2.20	2.40	1.95	1.20	3.20	.70	1.00	.90
16	.35	.45	.40	.55	4.90	1.95	1.80	1.60	3.10	.60	.90	.90
17	.30	.45	.20	.60	5.70	1.75	1.60	2.25	2.60	.80	.80	.90
18	.30	.55	.35	.65	4.70	1.65	1.80	3.00	2.00	.60	.80	.85
19	.30	.40	.30	2.85	3.80	1.55	6.00	3.40	1.60	.60	.80	.90
20	.40	.40	.35	3.20	4.90	1.35	7.70	4.50	1.60	.60	.80	.80
21	.35	.40	.40	3.10	4.85	1.40	6.60	4.70	2.10	.55	.80	.80
22	.30	.50	.40	2.55	5.55	1.35	5.10	3.20	2.40	.50	.80	.80
23	.25	.50	.40	2.10	4.00	1.40	3.80	2.60	1.90	.50	.80	.80
24	.30	.45	.35	1.90	4.00	1.55	3.30	3.00	1.50	.50	.80	.80
25	—.30	.45	.40	1.90	3.50	1.65	2.90	2.60	1.30	.55	.80	.80
26	—.05	.45	.30	2.80	3.50	1.95	2.40	2.25	1.20	.55	1.00	.85
27	—.10	.40	.30	3.00	3.00	2.25	2.10	1.90	1.20	.50	.90	.90
28	—.40	.45	.35	2.80	2.65	2.90	1.80	1.70	1.00	.50	.80	.85
29	+.10	.40	.45	2.00	2.30	2.90	1.70	1.45	1.00	.60	1.00	.80
30	.40	.....	.50	1.65	2.00	2.50	1.55	1.50	.90	.90	1.80	.80
31	.55	.....	.50	.....	2.20	.....	1.55	1.45	.....	2.15	.....	.80

Arkansas River at Canyon, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	2.40	2.40	2.50	3.05	4.45	2.30	2.40	2.60	2.15	2.30	3.55
2	2.50	2.45	2.30	2.60	3.05	4.00	2.30	2.30	2.50	2.10	2.30	5.50
3	2.50	2.40	2.30	2.60	3.30	3.95	2.25	2.20	2.25	2.10	2.30	3.00
4	2.50	2.50	2.30	2.50	3.35	3.70	2.30	2.00	2.20	2.10	2.30	.....
5	2.55	2.50	2.40	2.50	3.40	3.65	2.30	1.95	2.20	2.10	2.30	2.80
6	2.45	2.50	2.40	2.50	3.60	3.70	2.20	2.50	2.10	2.10	2.35	.....
7	2.50	2.60	2.40	2.50	3.80	3.50	2.20	2.35	2.10	2.05	2.40	.....
8	2.50	2.60	2.40	2.50	3.90	3.40	2.20	2.00	2.05	2.15	2.30	.....
9	2.50	2.50	2.50	2.40	3.75	3.30	2.20	1.90	1.95	2.20	2.35	.....
10	2.50	2.50	2.50	2.50	3.60	3.35	2.15	1.90	2.25	2.20	2.40	.....
11	2.50	2.50	2.50	2.40	3.55	3.40	2.20	1.90	2.30	2.20	2.50	.....
12	2.45	2.35	2.40	2.40	3.50	3.30	2.20	1.80	2.25	2.20	2.60	2.50
13	2.50	2.35	2.40	2.40	3.40	3.20	2.15	1.80	2.20	2.20	2.50	.....
14	2.50	2.45	2.40	2.60	3.20	3.10	2.10	1.80	2.15	2.20	2.50	.....
15	2.50	2.45	2.50	2.70	3.10	3.10	2.05	1.80	2.10	2.20	2.50	.....
16	2.50	2.45	2.50	2.80	3.00	3.00	2.96	1.80	2.10	2.20	2.50	.....
17	2.50	2.45	2.60	2.90	2.90	3.05	3.57	2.75	2.10	2.20	2.50	.....
18	2.50	2.45	2.60	2.85	2.80	3.00	3.20	2.45	2.20	2.10	2.40	.....
19	2.50	2.45	2.50	2.75	2.80	3.00	3.20	2.50	2.35	2.10	2.45	2.40
20	2.50	2.45	2.50	2.70	2.85	2.95	2.80	2.40	2.45	2.10	2.50	.....
21	2.50	2.45	2.40	2.60	2.95	2.90	2.70	2.60	2.30	2.10	2.60	.....
22	2.55	2.45	2.50	2.60	3.05	2.80	2.70	2.50	2.30	2.15	2.50	.....
23	2.55	2.55	2.60	2.50	3.15	2.80	2.60	2.50	2.30	2.20	2.50	.....
24	2.50	2.55	2.60	2.60	3.70	2.70	4.13	2.40	2.20	2.20	2.40	.....
25	2.50	2.50	2.80	2.75	3.80	2.70	2.90	2.35	2.20	2.20	2.40	.....
26	2.45	2.45	2.80	2.85	4.00	2.60	2.80	2.15	2.20	2.20	2.20	2.70
27	2.45	2.45	2.90	2.95	4.00	2.50	2.70	2.00	2.20	2.20	2.10	.....
28	2.45	2.40	3.20	3.00	4.20	2.50	2.60	1.95	2.20	2.20	2.00	.....
29	2.50	2.40	2.50	3.05	4.25	2.40	2.60	2.00	2.20	2.20	2.00	.....
30	2.50	.....	2.50	3.10	4.50	2.40	2.45	4.60	2.20	2.30	2.00	.....
31	2.45	.....	2.40	.....	4.60	.....	2.40	2.80	.....	2.30	.....	.....

Arkansas River at Pueblo, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.35	0.60	0.40	0.30	0.75	2.30	0.40	0.30	0.60	0.35	0.30	0.20
2	.40	.60	.40	.30	.65	1.95	.40	.20	.40	.30	.30	.30
3	.35	.60	.40	.30	.50	1.75	.30	.10	.35	.30	.30	.55
4	.35	.60	.40	.30	.85	1.70	.40	.10	.40	.20	.30	.60
5	.70	.60	.40	.30	1.25	1.65	.30	.10	.20	.20	.30	.55
6	.60	.60	.40	.30	1.40	1.60	.30	.10	.15	.20	.30	.50
7	.60	.60	.40	.30	1.65	1.60	.25	.10	.05	.20	.30	.50
8	.60	.60	.35	.40	1.85	1.45	.65	.10	.15	.20	.25	.60
9	.60	.60	.30	.30	1.80	1.25	.45	.05	.10	.20	.25	.55
10	.60	.60	.30	.30	1.50	1.35	.30	.00	.10	.30	.30	.50
11	.60	.60	.30	.30	1.40	1.25	.35	.00	.25	.30	.40	.40
12	.60	.60	.20	.40	1.45	1.05	.30	.00	.35	.30	.40	.35
13	.60	.50	.20	.40	1.45	.95	.25	.00	.35	.30	.30	.30
14	.60	.50	.40	.40	1.30	.85	.20	.00	.30	.30	.30	.45
15	.60	.60	.30	.40	1.00	.90	.20	.00	.20	.35	.30	.40
16	.60	.60	.40	.40	.90	.95	.20	.00	.20	.30	.35	.40
17	.60	.50	.35	.40	.90	.95	1.80	1.40	.15	.30	.35	.35
18	.60	.40	.40	.40	.85	.90	1.35	5.05	.15	.30	.30	.30
19	.60	.30	.40	.35	.80	.80	1.10	1.00	.45	.30	.25	.30
20	.60	.30	.40	.35	.75	.80	1.10	.80	.50	.20	.30	.30
21	.60	.30	.35	.25	.75	.50	.75	.40	.40	.20	.30	.30
22	.60	.30	.40	.15	.85	.80	.70	2.40	.65	.20	.30	.40
23	.60	.30	.40	.20	1.05	.70	.60	1.05	.40	.25	.50	.30
24	.60	.30	.40	.30	1.30	.60	2.83	.75	.25	.30	.45	.20
25	.60	.30	.40	.60	1.70	.60	2.05	.55	.25	.30	.40	.20
26	.60	.30	.40	.80	1.80	.60	.80	.40	.30	.30	.40	.35
27	.60	.30	.50	1.45	1.80	.60	.70	.40	.50	.30	.75	.40
28	.60	.30	.50	1.40	1.85	.45	.80	.30	.40	.20	.35	.30
29	.60	.30	.40	1.25	2.05	.50	.60	.25	.40	.40	.10	.30
30	.60	.....	.35	.90	2.05	.40	.50	.25	.40	.30	.10	.25
31	.60	.....	.30	.....	2.50	.....	.40	1.65	.....	.30	.....	.30

Purgatoire River at Trinidad, Colorado.

Day.	May.	June. [a]	July.	Aug.	Sept.	Oct.	Nov.
1	3.15	3.90	3.45	3.65	3.60	3.60	3.70
2	3.15	3.80	3.30	3.80	3.60	3.60	3.70
3	3.10	3.15	3.20	3.70	3.80	3.55	3.70
4	3.15	3.13	3.25	3.55	3.60	3.60	3.60
5	3.10	3.10	3.25	3.60	3.65	3.60	3.60
6	3.20	3.10	3.20	3.70	3.55	3.60	3.60
7	3.10	3.10	3.05	3.55	3.40	3.70	3.70
8	3.15	3.10	2.75	3.50	3.40	3.60	3.70
9	3.15	3.10	2.80	3.40	3.45	3.70	3.70
10	3.15	3.00	.....	3.40	3.45	3.70	3.70
11	3.10	3.00	3.35	3.30	3.40	3.70	3.70
12	3.15	2.85	3.10	3.30	3.35	3.70	3.65
13	3.20	2.75	2.95	3.60	3.30	3.70	3.60
14	3.30	2.55	2.80	3.25	3.30	3.75	3.60
15	3.15	.....	2.80	3.30	3.30	3.80	3.60
16	3.20	.....	3.80	3.30	3.30	3.80	3.60
17	3.20	.....	3.40	3.25	3.70	3.70	3.60
18	3.15	.....	3.45	4.65	3.80	3.70	3.60
19	3.15	2.80	3.50	3.40	3.85	3.70	3.60
20	3.15	2.80	3.40	3.50	3.80	3.70	3.60
21	3.05	.....	3.60	3.70	3.75	3.70	3.60
22	3.00	.....	3.30	3.60	4.20	3.70	3.60
23	3.00	.....	3.30	3.75	4.00	3.70	3.60
24	3.10	.....	4.80	3.65	3.90	3.75	3.60
25	3.10	.....	5.45	3.50	3.70	3.75	3.60
26	3.05	2.85	4.15	3.50	3.65	3.80	3.60
27	3.15	3.00	3.90	3.45	3.70	3.70	3.60
28	3.10	3.15	3.80	3.40	3.70	3.80	3.60
29	3.15	3.25	3.80	3.40	3.70	3.80	3.60
30	3.20	3.35	3.70	3.40	3.65	3.90	3.60
31	3.35	.....	3.70	5.05	.....	3.80	.....

[a] June 15 to 18, 20 to 26, river dry.

Arkansas River at Hutchinson, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.95	2.50	1.90	1.50	1.60	1.30	1.55	1.80	1.20	1.30	1.75	(a)
2	1.90	2.50	1.85	1.50	1.55	1.30	1.50	1.65	1.20	1.30	1.60	(a)
3	1.85	2.45	1.70	1.50	1.50	1.30	1.55	1.80	1.20	1.30	1.60	1.70
4	1.80	2.40	1.70	1.50	1.50	1.30	1.60	1.90	1.20	1.30	1.60	1.60
5	2.15	2.40	1.85	1.50	1.45	1.30	1.50	1.85	1.20	1.30	1.60	1.60
6	2.20	2.40	1.90	1.50	1.40	1.30	1.50	1.80	1.20	1.30	1.60	1.60
7	1.95	2.40	1.80	1.45	1.40	2.35	1.50	1.80	1.20	1.30	1.60	1.60
8	1.90	2.40	1.80	1.50	1.40	2.65	1.50	1.80	1.20	1.30	1.50	1.60
9	1.85	2.30	1.90	1.50	1.40	2.00	1.50	1.65	1.20	1.30	1.50	1.60
10	1.85	2.20	1.95	1.45	1.50	1.80	1.55	1.60	1.20	1.40	1.50	1.60
11	1.80	2.20	1.90	1.45	1.45	1.70	1.50	1.50	1.20	1.40	1.50	1.60
12	1.90	2.15	1.90	1.55	1.40	1.70	1.45	1.50	2.20	1.30	1.50	1.60
13	2.10	2.10	1.85	1.70	1.40	1.65	1.40	1.50	1.20	1.30	1.50	1.60
14	2.25	2.10	1.90	1.65	1.50	1.55	1.40	1.40	1.50	1.30	1.50	1.60
15	2.40	2.10	1.90	1.60	1.60	1.50	1.40	1.40	1.45	1.30	1.50	1.60
16	2.40	2.00	2.25	1.65	1.70	1.50	1.50	1.40	1.35	1.30	1.50	1.60
17	2.40	2.00	1.85	1.90	1.70	1.60	1.60	1.40	1.30	1.30	1.50	1.60
18	2.30	2.00	1.90	2.20	1.65	1.55	2.30	1.40	1.40	1.30	1.50	1.60
19	2.35	2.05	1.95	2.15	1.55	1.50	3.15	1.40	1.55	1.30	1.50	1.70
20	2.40	2.10	1.90	2.10	1.55	1.40	2.65	1.40	1.40	1.30	1.50	1.60
21	2.40	2.10	1.80	2.00	1.50	1.60	2.25	1.40	1.35	1.30	1.50	1.60
22	2.40	2.15	1.80	2.00	1.50	1.80	2.22	1.40	1.30	1.50	1.50	1.50
23	2.50	2.10	1.80	2.05	1.50	2.85	2.20	1.30	1.30	1.50	1.50	1.50
24	2.45	2.10	1.75	1.95	1.50	2.65	2.85	1.30	1.30	1.50	1.40	1.50
25	2.40	2.10	1.70	1.90	1.40	2.30	3.00	1.30	1.30	1.50	1.40	1.50
26	2.85	2.10	1.70	1.80	1.50	1.95	2.40	1.30	1.30	1.50	2.00	1.50
27	2.90	2.15	1.60	1.80	1.60	1.75	2.15	1.30	1.30	1.50	2.00	1.55
28	2.80	1.95	1.60	1.85	1.45	1.70	2.00	1.30	1.30	1.50	(a)	1.60
29	2.75	1.90	1.60	1.75	1.40	1.70	1.95	1.30	1.30	2.00	(a)	1.60
30	2.60	.....	1.55	1.65	1.30	1.60	1.85	1.30	1.30	2.05	(a)	1.50
31	2.50	.....	1.50	.....	1.30	.....	1.80	1.30	.....	1.85	.....	1.60

a Ice.

Verdigris River at Liberty, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.60	3.50	3.00	3.00	3.50	4.55	4.00	2.90	1.90	2.35	5.40	4.40
2	4.45	3.80	2.90	2.90	3.40	4.35	3.65	2.80	1.90	2.25	4.45	4.10
3	4.05	4.00	2.80	2.80	3.40	4.20	3.45	2.70	1.90	2.15	3.90	3.90
4	3.85	3.90	2.80	2.80	3.80	4.05	3.40	2.60	1.90	2.10	3.65	3.90
5	4.00	3.80	2.80	2.80	6.05	3.85	6.70	2.55	1.90	2.10	3.45	3.80
6	3.90	3.60	2.80	2.80	4.20	3.80	5.40	2.45	1.90	2.00	3.40	.....
7	3.90	3.60	2.80	2.80	3.55	3.65	4.35	2.35	1.95	2.00	3.30	3.80
8	3.90	3.50	2.80	2.80	3.25	14.75	3.80	2.30	1.95	2.00	3.20	.....
9	3.90	3.40	2.80	2.80	3.05	21.66	3.50	2.10	1.90	1.95	3.20	.....
10	3.90	3.30	2.80	3.00	2.90	12.75	3.40	2.10	1.80	1.90	3.10	3.80
11	3.90	3.40	2.80	5.40	2.80	5.25	3.30	2.10	1.80	1.90	3.10	.....
12	3.90	3.40	2.80	4.40	2.70	4.65	3.20	2.10	1.70	1.90	3.00	3.60
13	3.90	3.40	2.80	3.80	2.70	4.15	3.10	2.10	1.70	1.90	2.95	.....
14	3.90	3.40	2.80	3.50	2.70	3.95	3.00	2.10	1.70	1.90	2.90	3.40
15	3.90	3.40	2.80	3.40	2.70	3.75	2.90	2.10	1.70	1.85	2.80	.....
16	3.90	3.30	2.80	3.30	8.45	3.55	2.80	2.10	1.70	1.80	2.80	3.20
17	3.80	3.30	3.00	3.20	11.25	3.40	2.70	2.00	1.70	1.80	2.70	.....
18	3.70	3.30	3.10	3.10	10.65	3.30	2.70	2.00	1.70	1.80	2.70	3.10
19	3.70	3.20	3.20	3.00	6.80	3.20	7.00	2.00	2.60	1.80	2.65	.....
20	3.70	3.20	3.20	3.00	12.25	3.10	16.25	2.00	3.35	1.80	2.60	.....
21	3.70	3.10	3.20	3.10	9.95	3.10	16.50	2.00	3.20	1.80	2.60	3.00
22	3.70	3.00	3.20	3.15	6.45	3.15	15.25	2.00	3.00	1.90	2.60	.....
23	3.70	3.00	3.20	3.50	12.65	3.20	7.00	2.00	2.85	2.40	2.60	3.00
24	3.70	3.00	3.20	3.15	23.75	3.20	4.70	2.00	2.65	3.70	2.60	.....
25	3.60	3.00	3.10	5.55	22.75	3.25	4.10	2.00	2.50	4.50	2.60	3.00
26	3.50	3.00	3.10	8.10	20.50	3.45	3.90	2.00	2.50	3.85	2.80	.....
27	3.40	3.00	3.10	6.20	19.25	8.40	3.80	2.00	2.50	3.30	14.50	.....
28	3.40	3.00	3.10	4.85	13.00	12.50	3.65	2.00	2.50	3.05	14.00	.....
29	3.40	3.00	3.00	4.45	6.55	8.10	3.45	2.00	2.45	5.25	6.85	.....
30	3.40	.....	3.00	3.90	5.25	4.65	3.15	1.90	2.40	14.00	4.80	.....
31	3.40	.....	3.00	.....	4.80	.....	3.00	1.90	.....	8.50	.....	.....

Neosho River at Iola, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.95	2.95	2.40	2.30	3.60	4.40	3.30	3.00	2.10	2.10	3.70	3.25
2	2.80	2.95	2.40	2.30	3.40	4.00	3.30	2.85	2.10	2.10	3.35	3.15
3	2.60	2.90	2.40	2.30	3.15	3.90	3.30	2.80	2.10	2.10	2.60	2.85
4	2.50	2.70	2.40	2.30	7.58	3.80	4.35	2.70	2.10	2.10	2.40	2.65
5	2.70	2.70	2.45	2.30	5.00	3.70	4.95	2.60	2.10	2.00	2.35	2.55
6	2.65	2.70	2.45	2.30	3.85	3.70	3.90	2.55	2.10	2.00	2.35	2.50
7	2.55	2.65	2.40	2.30	3.75	3.80	3.80	2.50	2.10	2.00	2.45	2.50
8	2.50	2.55	2.40	3.95	3.40	6.45	3.50	2.40	2.10	2.00	2.40	2.50
9	2.55	2.50	2.40	10.25	3.00	4.85	3.35	2.30	2.10	2.00	2.40	2.50
10	2.50	2.50	2.40	8.10	2.90	4.30	3.20	2.30	2.10	2.00	2.30	2.45
11	2.50	2.50	2.30	6.85	2.85	4.00	2.95	2.30	2.10	2.00	2.30	2.40
12	2.55	2.50	2.30	4.50	2.80	3.95	2.80	2.30	2.10	2.00	2.30	2.40
13	2.50	2.50	2.30	3.75	2.70	3.70	2.75	2.30	2.00	2.00	2.30	2.40
14	2.55	2.50	2.20	3.50	2.70	3.45	2.70	2.20	2.00	2.00	2.25	2.40
15	2.50	2.50	2.20	3.35	3.75	3.35	2.60	2.20	2.00	2.00	2.20	2.40
16	2.50	2.50	2.30	3.35	11.55	3.25	2.60	2.20	2.00	2.10	2.20	2.40
17	2.55	2.40	2.30	3.45	9.45	3.15	2.60	2.20	2.00	2.10	2.20	2.35
18	2.60	2.40	2.30	3.20	7.10	3.05	2.65	2.20	2.00	2.00	2.20	2.30
19	2.60	2.40	2.30	3.05	6.40	3.00	4.45	2.15	2.00	2.10	2.20	2.30
20	2.60	2.40	2.20	3.00	5.55	3.00	5.45	2.10	2.00	2.10	2.20	2.30
21	2.60	2.40	2.20	2.80	4.85	2.95	7.20	2.10	2.00	2.10	2.20	2.30
22	2.60	2.40	2.20	2.90	16.25	2.90	7.75	2.10	2.00	2.05	2.10	2.30
23	2.60	2.40	2.30	4.25	18.25	2.90	5.65	2.10	2.00	2.05	2.10	2.20
24	2.60	2.40	2.40	3.00	20.10	2.90	4.30	2.10	2.10	2.00	2.10	2.20
25	2.60	2.40	2.60	9.50	19.05	3.40	4.00	2.10	2.10	2.00	2.15	2.20
26	2.60	2.40	2.50	7.70	16.50	3.60	3.65	2.10	2.10	2.00	2.80	2.20
27	2.50	2.40	2.40	9.40	15.25	3.45	3.50	2.10	2.10	2.00	4.85	2.20
28	2.50	2.40	2.40	6.95	10.75	3.65	3.30	2.10	2.10	2.00	4.00	2.20
29	2.50	2.40	2.35	4.50	5.70	3.45	3.30	2.10	2.10	2.00	3.55	2.20
30	2.55	.....	2.30	3.85	5.05	3.40	3.20	2.10	2.10	2.05	3.45	2.20
31	2.75	.....	2.30	.....	4.65	.....	3.10	.....	.....	2.85	.....	2.20

Medicine River at Kiowa, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June. *a*	July.	Aug.	Sept. *b*	Oct.
1	2.50	2.50	2.40	2.40	2.80	2.80	3.65	2.40	1.40	2.10
2	2.60	2.50	2.40	2.40	2.50	2.80	3.50	2.40	1.40	2.20
3	2.60	2.50	2.40	2.40	2.50	2.20	3.10	2.40	1.40	2.20
4	2.70	2.60	2.40	2.40	2.50	2.20	2.80	2.40	1.40	2.20
5	2.70	2.60	2.30	2.20	2.50	2.10	2.80	2.40	1.40	2.20
6	2.60	2.60	2.30	2.20	2.40	1.90	2.70	2.40	1.40	2.10
7	2.60	2.70	2.30	2.00	2.40	1.65	2.60	2.30	1.40	2.20
8	2.60	2.70	2.40	2.00	2.40	1.30	2.60	2.30	1.40	2.20
9	2.60	2.70	2.40	2.00	2.30	1.40	2.60	2.00	.....	2.20
10	2.70	2.70	2.40	1.90	2.20	1.20	2.90	2.00	.....	2.30
11	2.80	2.60	2.40	1.90	2.20	1.20	2.95	2.00	.....	2.35
12	2.70	2.60	2.50	2.20	2.20	1.20	2.90	1.90	.....	2.40
13	2.60	2.60	2.60	2.50	2.30	1.20	2.85	1.90	2.00	2.40
14	2.60	2.60	2.60	2.55	2.30	.....	3.25	1.80	2.00	2.40
15	2.60	2.60	2.70	2.60	2.30	.....	3.80	1.80	2.00	2.40
16	2.70	2.50	2.65	2.60	2.20	.....	5.90	1.80	2.00	2.40
17	2.80	2.50	2.60	2.60	2.10	.....	5.00	1.80	2.00	2.30
18	2.75	2.60	2.50	2.75	2.10	.....	4.70	1.80	2.00	2.30
19	2.65	2.70	2.50	3.75	2.15	.....	5.60	1.80	2.10	2.30
20	2.60	2.70	2.50	3.70	2.20	.....	4.90	1.70	2.35	2.40
21	2.50	2.70	2.50	3.15	2.35	2.00	3.70	1.70	2.40	2.40
22	2.50	2.60	2.50	2.75	2.40	2.20	3.60	1.70	2.20	2.55
23	2.50	2.50	2.60	2.70	3.20	4.00	3.40	1.70	2.20	2.80
24	2.50	2.50	2.60	2.65	3.00	2.95	3.00	1.60	2.20	2.90
25	2.60	2.40	2.60	2.50	2.80	2.93	2.75	1.60	2.20	2.85
26	2.60	2.40	2.60	2.50	2.70	5.50	2.75	1.50	2.20	2.80
27	2.60	2.40	2.60	2.60	2.60	5.35	2.60	1.50	2.10	2.60
28	2.60	2.50	2.50	2.80	2.55	4.75	2.50	1.40	2.10	2.60
29	2.60	2.50	2.45	2.85	2.45	4.25	2.50	1.40	2.10	3.00
30	2.50	.....	2.40	2.80	2.40	3.95	2.55	1.40	2.10	2.95
31	2.50	.....	2.40	.....	2.30	.....	2.50	1.40	.....	2.75

a Water standing in pools from June 14 to 21.
b Water standing in pools from September 9 to 13.

Cimarron River at Arkalon, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.50	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.30
2	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
3	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
4	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
5	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
6	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
7	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
8	2.50	2.50	2.50	2.50	2.50	2.40	2.30	2.40	2.30	2.30
9	2.50	2.50	2.50	2.50	2.50	2.40	2.30	2.40	2.30	2.30
10	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.40	2.30	2.30
11	2.50	2.50	2.50	8.00	2.40	2.40	2.30	2.40	2.30	2.30
12	2.50	2.50	2.50	4.15	2.50	2.40	2.30	2.40	2.30	2.30
13	2.50	2.50	2.50	3.00	2.50	2.40	2.30	2.40	2.30	2.30
14	2.50	2.50	2.50	2.80	2.50	2.40	2.30	2.40	2.30	2.30
15	2.40	2.50	2.50	2.70	2.50	2.40	2.65	2.40	2.30	2.50
16	2.50	2.50	2.50	2.60	2.50	2.40	2.65	2.35	2.30	2.50
17	2.50	2.50	2.50	2.60	2.50	2.40	2.50	2.30	2.30	2.50
18	2.50	2.50	2.50	2.60	2.50	2.40	2.50	2.30	2.30	2.50
19	2.50	2.50	2.50	2.50	2.50	2.30	2.50	2.30	2.30	2.50
20	2.50	2.50	2.50	2.50	2.50	2.30	2.50	2.30	2.30	2.50
21	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
22	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
23	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
24	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
25	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
26	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
27	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
28	2.50	2.50	2.50	2.50	2.50	2.40	2.45	2.30	2.30	2.50
29	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.30	2.50
30	2.40	.....	2.50	2.50	2.50	2.40	2.40	2.30	2.30	2.50
31	2.40	.....	2.50	.....	2.50	.....	2.40	2.30	.....	2.50

Mora River at Watrous, New Mexico.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	1.90	1.95	9	1.90	1.90	17	1.90	1.90	25	1.90	1.90
2	1.90	1.95	10	1.90	1.90	18	1.95	1.90	26	1.90	1.90
3	1.90	1.95	11	1.90	1.90	19	1.95	1.90	27	1.95	1.90
4	1.90	1.92	12	1.90	1.90	20	1.95	1.90	28	1.95	1.90
5	2.02	1.92	13	1.90	1.90	21	1.95	1.90	29	1.95	1.90
6	2.00	1.92	14	1.90	1.90	22	1.90	1.90	30	1.95	.....
7	1.90	1.92	15	1.90	1.90	23	1.90	1.90	31	1.95	.....
8	1.90	1.92	16	1.90	1.90	24	1.90	1.90			

Rio Grande at Del Norte, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.12	2.96	3.12	2.08	4.18	3.62	1.74	1.56	1.60	2.06	1.72	.....
3	3.24	3.02	3.18	2.14	4.56	3.38	1.70	1.52	1.50	2.00	1.64	.....
5	3.28	2.98	3.10	2.46	4.52	3.06	1.64	1.54	1.54	1.98	1.60	1.62
7	3.16	2.86	3.14	3.08	4.30	2.88	1.62	1.52	1.48	1.94	1.58	.....
9	3.20	2.80	3.10	3.20	3.96	2.72	1.68	1.48	1.50	1.88	1.60	.....
11	3.22	2.90	3.04	3.02	3.66	2.52	1.64	1.46	1.74	1.86	1.72	.....
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.80
13	3.08	2.78	3.16	2.98	3.32	2.34	1.72	1.44	1.62	1.82	1.58	.....
15	3.12	2.72	3.02	3.04	3.24	2.20	1.70	1.42	1.58	1.94	1.56	.....
17	3.18	2.78	2.84	2.94	3.06	2.12	1.92	1.42	1.50	1.84	1.54	.....
19	3.26	3.20	2.76	2.76	3.22	2.10	2.22	1.44	1.52	1.82	1.52	1.72
21	3.22	3.24	2.54	2.78	3.54	1.98	1.92	1.42	2.00	1.78	1.50	.....
23	3.16	3.18	2.50	3.04	3.80	1.92	1.80	1.46	2.28	1.78	1.54	.....
25	3.12	3.24	2.68	3.90	4.00	1.86	1.78	1.44	3.16	1.80	1.52	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.64
27	3.06	3.20	2.54	4.22	4.08	1.82	1.70	1.40	2.68	1.84	1.48	.....
29	3.00	3.14	2.52	4.04	4.02	1.78	1.64	1.74	2.18	1.82	1.52	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.64	.....
31	2.98	.....	2.50	4.12	3.94	.....	1.58	1.62	.....	1.76	.....	.....

Rio Grande at Embudo, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.35	8.30	8.50	9.50	10.70	9.15	7.30	7.30	7.30	9.30	7.50	8.10
2	8.25	8.30	8.50	9.50	10.65	8.95	7.30	7.30	7.30	8.65	7.40	8.10
3	8.20	8.10	8.55	9.50	10.45	8.80	7.30	7.30	7.30	7.45	7.40	8.00
4	8.35	8.00	8.40	9.45	10.55	8.45	7.30	7.30	7.30	7.50	7.30	8.00
5	8.30	8.05	8.35	9.55	10.85	8.40	7.30	7.30	7.30	7.50	7.30	8.00
6	8.20	8.20	8.35	9.70	11.00	8.25	7.30	7.30	7.30	7.50	7.30	8.00
7	8.30	8.20	8.40	10.05	10.90	8.20	7.30	7.30	7.30	7.50	7.30	8.00
8	8.35	8.30	8.35	10.10	10.65	8.00	7.30	7.30	7.30	7.50	7.30	8.00
9	8.30	8.30	8.30	10.10	10.40	7.90	7.30	7.30	7.30	7.50	7.40	8.00
10	8.30	8.20	8.40	10.20	10.25	7.75	7.30	7.30	7.30	7.50	7.45	7.90
11	8.50	8.15	8.50	10.30	10.10	7.60	7.30	7.30	7.30	7.50	7.50	7.90
12	8.55	8.10	8.60	10.30	9.85	7.60	7.30	7.30	7.30	7.50	7.50	7.90
13	8.10	8.20	8.55	10.30	9.65	7.50	9.65	7.30	7.30	7.50	7.60	7.90
14	8.00	8.25	8.65	10.30	9.60	7.50	7.30	7.30	7.30	7.50	7.40	7.90
15	8.00	8.10	8.70	10.30	9.50	7.50	7.30	7.30	7.30	7.50	7.40	7.90
16	8.10	8.05	8.75	10.30	9.40	7.50	7.30	7.30	7.30	7.50	7.55	7.90
17	8.05	8.20	8.75	10.30	9.40	7.40	7.45	7.30	7.30	7.50	7.95	7.85
18	8.10	8.25	8.60	10.30	9.40	7.40	7.50	7.30	7.30	7.50	8.30	7.80
19	8.00	8.25	9.10	10.05	9.25	7.35	7.50	7.30	7.30	7.50	8.40	7.80
20	8.00	8.30	9.10	9.90	9.10	7.30	7.60	7.30	7.30	8.00	8.40	7.80
21	8.00	8.20	9.05	9.70	9.00	7.30	8.70	7.45	7.30	7.85	8.35	7.80
22	8.10	8.25	8.85	9.70	8.90	7.30	7.30	7.60	7.30	7.70	8.50	7.80
23	8.10	8.20	9.15	9.70	8.90	7.30	8.05	7.40	7.30	7.70	8.50	7.80
24	8.10	8.25	9.35	9.70	8.90	7.30	8.00	7.40	7.30	7.70	8.35	7.80
25	8.00	8.30	9.55	9.80	8.90	7.30	7.40	7.35	7.30	7.70	8.25	7.80
26	8.00	8.30	9.60	9.80	9.00	7.30	7.40	7.30	7.30	7.70	8.20	7.80
27	8.10	8.40	9.70	9.95	9.50	7.30	7.50	7.30	7.30	7.70	8.20	7.80
28	8.20	8.45	10.10	10.65	9.50	7.30	7.50	7.30	7.45	7.70	8.10	.....
29	8.25	8.45	10.30	10.80	9.50	7.30	7.40	7.30	7.70	7.70	8.10	.....
30	8.25	.....	10.20	10.80	9.50	7.30	7.40	7.30	8.30	7.70	8.10	.....
31	8.30	.....	10.00	.....	9.50	7.30	7.30	7.30	.....	7.70	.....	.....

Chama River at Abiquiu, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	1.05	.....	1.90	3.05	1.90	1.70	2.25	2.45	2.25	2.25	2.15
2	1.80	.95	.....	2.45	3.35	1.90	1.50	2.10	2.85	2.35	2.45	1.90
3	1.80	1.15	.....	1.80	2.85	1.85	1.50	2.05	2.75	2.25	2.25	2.05
4	1.85	1.20	.....	1.95	2.65	1.05	1.50	1.95	2.85	2.85	2.25	2.20
5	1.75	1.15	.....	2.95	2.65	1.10	1.35	1.80	2.75	2.70	2.40	2.10
6	1.70	1.00	.....	2.85	2.50	1.05	1.30	1.70	2.20	2.85	2.30	2.00
7	1.75	1.10	.....	3.25	2.90	1.45	1.30	1.65	2.65	3.30	2.25	1.90
8	1.70	1.55	.....	4.13	2.85	1.35	1.35	1.50	3.35	3.40	2.30	2.05
9	1.65	1.55	.....	3.60	2.75	1.45	1.80	1.60	3.40	3.15	2.25	2.00
10	1.55	1.20	.....	2.85	2.75	1.75	1.50	1.55	4.40	2.90	2.05	2.00
11	1.70	1.10	1.60	2.70	2.65	1.45	1.55	1.55	4.40	2.80	2.10	1.95
12	1.75	1.30	1.75	2.80	2.50	1.55	1.45	1.60	3.65	2.75	2.25	2.10
13	1.80	1.45	1.90	2.35	2.45	1.35	1.45	1.50	3.45	2.65	2.15	1.90
14	1.75	1.55	1.70	3.65	2.55	1.30	3.75	1.50	2.90	2.70	2.30	2.05
15	1.70	1.10	1.95	3.05	2.35	1.60	2.75	1.45	2.75	2.75	2.25	2.05
16	1.80	.95	1.50	3.35	2.15	1.45	3.15	1.50	2.55	2.70	2.15	2.10
17	1.75	.95	1.50	3.30	2.55	1.35	3.55	1.55	3.15	2.65	2.25	1.95
18	1.75	1.00	1.55	3.40	2.25	1.30	3.00	1.45	3.15	2.60	2.25	2.00
19	1.65	1.45	1.30	2.55	2.35	1.40	3.25	1.50	3.45	2.75	2.10	1.95
20	1.45	1.40	1.30	3.40	2.15	1.10	3.35	1.35	3.05	2.70	2.15	2.05
21	1.70	1.20	1.35	3.85	1.95	1.10	2.85	1.45	2.80	2.75	2.25	2.15
22	1.35	1.10	1.35	4.10	1.85	1.10	3.60	1.50	2.60	2.65	2.10	2.15
23	1.65	1.50	1.45	3.85	2.05	1.25	2.70	1.85	2.55	2.75	2.10	2.05
24	1.70	1.75	1.55	2.95	2.15	1.30	3.50	1.85	2.55	2.85	2.00	1.95
25	1.55	1.55	1.50	3.70	2.10	1.40	2.95	1.80	2.50	2.85	2.35	1.85
26	1.55	1.35	1.70	3.85	2.15	1.25	2.85	1.90	2.30	2.85	2.35	2.00
27	1.55	1.60	2.55	3.85	1.55	1.50	2.75	1.35	2.25	2.85	2.30	.....
28	1.65	2.05	2.25	3.55	1.85	1.70	2.75	1.35	2.35	2.55	2.35	.....
29	1.35	2.15	1.85	3.35	2.10	1.65	2.95	1.45	2.30	2.65	2.15	.....
30	.90	.....	1.95	3.25	1.85	1.70	2.85	1.45	2.20	2.75	2.20	.....
31	1.10	.....	1.70	.....	1.55	.....	2.75	1.15	.....	2.60	.....	.....

Rio Grande at Rio Grande, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	.....	.....	6.65	8.25	6.30	4.20	.....	4.25	4.85	4.80	4.40
2	4.90	.....	.....	6.50	7.95	6.25	4.30	4.10	4.20	4.80	4.80	4.70
3	5.05	.....	.....	6.45	7.85	6.10	4.25	4.10	4.15	4.75	4.80	4.90
4	5.15	.....	5.50	6.45	7.90	5.90	4.25	4.00	4.10	4.70	4.75	4.90
5	.....	.....	5.35	6.40	8.10	5.65	4.20	4.00	4.10	4.65	4.70	4.80
6	.....	.....	5.30	6.55	8.15	5.40	4.25	3.98	4.18	4.60	4.70	4.90
7	.....	.....	5.25	6.85	8.35	5.30	4.10	3.90	4.20	4.53	4.58	4.95
8	.....	.....	5.40	7.02	8.50	5.20	4.10	3.90	4.05	4.95	4.58	5.00
9	.....	.....	5.40	7.50	8.35	5.00	4.08	3.90	4.00	4.85	4.65	5.05
10	.....	.....	5.45	7.60	7.75	4.85	4.03	3.90	4.35	5.00	4.70	5.05
11	.....	.....	5.55	7.80	7.45	4.70	4.00	3.88	4.55	4.80	4.70	5.05
12	.....	.....	5.55	7.87	7.25	4.55	4.00	3.83	4.95	4.70	5.00	5.00
13	.....	.....	5.70	7.80	7.10	4.50	4.60	3.85	4.40	4.80	5.10	5.05
14	.....	.....	5.80	7.65	7.00	4.50	5.10	3.80	4.40	4.90	5.10	5.10
15	.....	.....	5.85	7.80	6.90	4.48	4.30	3.80	4.30	5.00	5.10	4.95
16	.....	.....	5.70	7.80	6.55	4.30	4.65	3.80	4.20	4.98	5.10	5.00
17	.....	5.20	5.75	7.95	6.45	4.25	4.85	3.80	4.20	4.75	5.10	5.10
18	.....	5.20	5.65	7.90	6.30	4.20	4.70	3.80	4.80	4.65	5.10	5.00
19	.....	5.20	5.60	7.75	6.00	4.20	5.40	3.80	4.30	4.75	5.10	4.85
20	.....	5.20	5.52	7.50	5.95	4.15	4.75	3.80	4.45	4.70	5.10	4.75
21	.....	5.20	5.80	7.45	5.85	4.10	5.00	3.80	4.50	4.70	5.10	4.80
22	.....	5.20	5.80	7.60	5.80	4.10	5.40	3.73	4.40	4.75	5.10	4.80
23	.....	.....	5.95	7.70	5.80	4.05	5.15	3.70	4.40	5.15	5.10	4.80
24	.....	.....	6.25	7.60	5.85	4.00	4.95	4.33	4.45	5.00	5.10	4.75
25	.....	.....	6.40	7.85	6.00	4.00	4.65	3.95	4.35	5.00	5.15	4.70
26	.....	.....	6.65	7.95	6.25	4.25	4.65	3.90	4.25	4.90	5.13	4.55
27	.....	.....	6.95	8.15	6.35	4.10	4.50	4.00	4.20	4.90	4.95	.....
28	.....	.....	7.20	8.35	6.40	4.10	4.25	4.00	4.30	5.05	4.85	.....
29	.....	.....	7.25	8.40	6.35	4.15	4.20	4.00	5.35	4.90	4.30	.....
30	.....	.....	7.15	8.45	6.45	4.20	4.30	4.00	5.10	4.80	4.35	.....
31	.....	.....	6.90	.....	6.30	.....	4.25	4.13	.....	4.80	.....	.....

Rio Grande at San Marcial, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.45	7.20	8.60	9.00	7.30	a5.60	6.00	b5.50	b5.50	6.80	7.20
2	.....	7.55	7.20	8.45	9.00	7.30	a5.60	6.00	b5.50	b5.50	6.65	7.20
3	.....	7.50	7.20	8.30	8.50	7.50	a5.60	6.00	b5.50	b5.50	6.50	7.20
4	.....	7.40	7.20	8.10	8.50	7.40	a5.60	6.00	b5.50	b5.50	6.50	7.20
5	.....	7.40	7.20	7.90	8.50	7.40	7.00	6.00	b5.50	b5.50	6.50	7.20
6	.....	7.40	7.20	7.90	8.50	7.50	7.00	7.00	b5.50	b5.50	6.50	7.20
7	.....	7.35	7.20	8.00	8.50	7.00	b6.60	6.65	b5.50	b5.50	6.50	7.20
8	.....	7.30	7.00	8.00	8.50	7.00	b6.00	5.85	b5.50	b5.50	6.90	7.20
9	.....	7.30	7.00	8.10	8.70	7.00	b6.00	(b)	b5.50	b5.50	6.90	7.20
10	.....	7.30	7.10	8.20	8.70	6.65	b6.00	(b)	b5.50	b5.50	6.90	7.20
11	.....	7.30	7.10	8.30	8.70	6.40	b6.00	(b)	b5.50	b5.50	6.90	7.30
12	.....	7.30	7.10	8.40	8.70	6.20	b6.00	(b)	b5.50	b5.50	6.90	7.30
13	.....	7.30	7.00	8.70	8.50	a6.00	b6.00	(b)	b6.25	6.95	6.90	7.30
14	.....	7.30	7.00	8.90	8.50	a6.00	b6.00	(b)	6.65	9.45	6.90	7.50
15	.....	7.50	7.20	8.90	8.30	a6.00	b6.00	(b)	5.75	11.00	7.00	7.50
16	.....	7.40	7.20	8.60	8.20	a6.00	b6.00	b5.50	b5.50	8.50	7.00	7.50
17	.....	7.40	7.40	8.50	8.00	a6.00	b6.00	b5.50	b5.50	7.00	7.00	7.25
18	.....	7.40	7.40	8.60	7.50	a6.00	b6.55	b5.50	b5.50	7.00	7.00	7.25
19	.....	7.40	7.40	8.65	7.50	a6.00	6.70	b5.50	b5.50	7.00	7.00	7.40
20	.....	7.40	7.58	8.40	7.50	a5.90	7.50	b5.50	7.50	7.25	7.00	7.35
21	.....	7.45	7.60	8.40	7.50	a5.60	9.00	b5.50	7.95	6.00	7.00	7.30
22	7.50	7.50	7.40	8.40	7.20	a5.60	8.25	b5.50	7.60	6.00	7.00	7.30
23	7.45	7.40	7.40	8.40	7.00	a5.60	7.60	b5.50	7.00	6.00	7.10	7.30
24	7.40	7.40	7.50	8.40	7.00	a5.60	7.00	b5.50	7.00	6.95	7.10	7.50
25	7.40	7.40	7.50	8.45	7.00	a5.60	7.00	b5.50	6.75	6.80	7.10	7.50
26	7.50	7.40	7.50	9.00	7.00	a5.60	6.50	7.50	b6.50	6.80	7.10	7.43
27	7.60	7.30	7.60	9.00	7.00	a5.60	6.90	7.50	b6.50	6.80	7.10	.....
28	7.45	7.30	7.70	9.00	7.00	a5.60	8.00	7.50	b6.50	6.80	7.10	.....
29	7.40	7.30	7.90	9.00	7.00	a5.60	8.00	7.45	b6.50	6.80	7.22	.....
30	7.30	.....	7.90	9.00	6.95	a5.60	7.50	6.90	b6.50	6.80	7.20	.....
31	7.40	.....	8.20	.....	7.10	.....	7.00	b5.50	.....	6.80	.....	.....

a No water running. *b* Dry.

Rio Grande at El Paso, Texas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.85	7.30	6.60	6.00	8.65	5.40	5.10	6.70	0.00	5.55	7.25	6.55
2	6.05	7.30	6.70	7.20	8.80	5.35	5.80	6.55	5.70	7.05	7.15	6.60
3	5.95	7.30	6.85	8.55	8.80	5.35	5.25	6.40	5.25	7.60	6.90	6.60
4	6.00	7.30	6.90	8.60	8.80	5.30	5.15	6.30	5.25	7.50	6.80	6.60
5	5.95	7.30	6.80	8.45	8.80	5.30	5.10	6.05	5.05	8.00	6.70	6.50
6	6.10	7.30	6.70	8.35	8.80	5.25	5.10	5.35	4.80	7.45	6.65	6.50
7	6.20	7.35	6.70	8.15	8.80	5.20	4.90	5.55	.00	7.50	6.60	6.50
8	6.30	7.50	6.70	7.90	8.70	5.25	.00	5.45	.00	7.30	6.60	6.60
9	6.30	7.45	6.75	7.70	8.50	5.15	.00	5.35	.00	7.05	6.50	6.55
10	6.25	7.35	7.70	7.55	8.50	5.15	.00	5.35	.00	7.40	6.40	6.55
11	6.15	7.25	7.35	7.45	8.65	5.15	.00	5.25	.00	7.20	6.35	6.50
12	6.40	7.20	7.30	7.30	8.75	4.95	.00	5.25	.00	7.00	6.30	6.40
13	6.40	7.10	7.10	7.50	8.85	5.05	.00	5.20	.00	6.90	6.20	6.35
14	7.35	7.10	7.00	8.05	8.75	5.10	.00	5.20	.00	7.00	6.10	6.40
15	7.40	7.05	6.80	8.95	8.65	5.00	.00	5.00	.00	8.65	6.10	6.50
16	7.40	7.20	6.50	8.90	8.55	4.80	.00	4.90	.00	10.15	6.10	6.40
17	7.60	7.10	6.40	8.65	8.35	4.45	5.15	4.75	.00	10.60	6.10	6.40
18	7.40	7.00	6.30	8.50	8.10	4.30	8.38	4.60	.00	10.55	6.10	6.35
19	7.45	6.90	6.20	8.45	8.00	4.10	7.35	4.60	.00	8.75	6.10	6.50
20	7.50	6.95	6.10	8.45	7.85	3.80	7.25	4.40	.00	8.15	6.10	6.70
21	7.45	7.15	6.10	8.65	7.65	.....	7.10	4.30	.00	7.75	6.10	6.70
22	7.30	7.25	6.10	8.90	7.30	.....	7.90	4.60	.00	7.65	6.10	6.70
23	7.30	7.20	6.05	8.80	7.15	.....	7.70	4.40	5.50	7.55	6.10	6.70
24	7.25	7.05	6.35	8.60	7.00	.....	9.60	.00	5.70	7.30	6.10	6.70
25	7.35	7.00	6.75	8.40	6.85	.....	8.70	.00	7.35	7.75	6.30	6.65
26	7.25	7.00	6.65	8.50	6.65	.....	8.20	.00	6.80	8.10	6.30	6.70
27	7.30	7.00	6.35	8.45	6.45	.....	7.55	.00	6.20	8.00	6.40	.....
28	7.20	6.80	6.20	8.50	6.15	.00	7.10	.00	6.05	8.20	6.60	.....
29	7.20	6.70	6.10	8.55	5.95	.00	7.20	.00	6.00	7.70	6.55	.....
30	7.10	.....	6.00	8.55	5.70	.00	7.10	.00	5.75	7.45	6.50	.....
31	7.35	.....	5.90	.....	5.45	.....	7.00	.00	.....	7.25	.....	.....

Grand River at Grand Junction, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.70	4.65	1.20	1.05	3.35	4.10	3.50	.....
2	.....	2.65	4.10	1.20	.95	3.40	4.00	3.50	.....
3	.....	2.65	3.65	1.10	.85	3.50	3.95	3.50	3.00
4	.....	3.20	3.45	1.10	.85	3.40	3.85	3.40	.....
5	.....	3.30	3.30	1.05	.70	3.30	3.80	3.30	3.30
6	.....	3.90	3.30	1.00	.70	3.25	3.80	3.20	.....
7	.....	4.00	3.25	1.05	.65	3.15	3.80	3.20	.....
8	.....	4.30	3.15	1.00	.55	3.30	3.70	3.10	.....
9	.....	3.90	2.90	.90	.45	3.50	3.70	3.00	3.10
10	.....	3.80	2.75	.85	.40	4.85	3.70	3.20	.....
11	.....	3.70	3.05	.80	.25	4.30	3.70	3.30	.....
12	1.10	3.55	2.95	.80	.15	4.40	3.70	3.30	3.00
13	1.20	3.20	2.80	.80	.05	4.35	3.70	3.30	.....
14	1.10	2.90	2.45	.85	.00	4.15	3.70	3.20	.....
15	1.30	2.50	2.35	.90	.00	3.95	3.65	3.30	.....
16	1.45	2.30	2.20	.85	.00	3.70	3.60	3.40	.....
17	1.50	1.90	2.15	.85	.00	3.60	3.60	3.40	.....
18	1.50	1.90	2.05	1.00	.00	3.60	3.55	3.25	3.10
19	1.20	1.85	2.00	1.25	.00	3.90	3.50	3.10	3.10
20	1.15	1.85	2.00	1.25	.00	3.80	3.50	3.25	.....
21	1.10	1.90	1.85	1.10	1.63	3.75	3.50	3.40	.....
22	1.10	1.90	1.80	1.00	.40	3.80	3.50	3.40	.....
23	1.60	2.35	1.75	.85	a3.45	7.20	3.50	3.40	.....
24	1.90	3.25	1.65	.80	3.55	5.70	3.50	3.40	2.90
25	2.50	3.70	1.55	1.00	3.90	4.55	3.50	3.40	.....
26	2.70	3.90	1.50	1.40	3.75	4.45	3.50	3.40	.....
27	3.30	4.05	1.50	1.45	3.55	4.40	3.40	3.30	.....
28	3.70	4.45	1.40	1.55	3.35	4.30	3.50	3.10	.....
29	3.15	4.30	1.30	1.55	3.30	4.30	3.50	2.70	2.80
30	2.90	4.55	1.30	1.35	3.30	4.10	3.50	2.50	.....
31	.....	4.40	.....	1.15	3.30	.....	3.50	.....	3.00

a New rod placed in position reading 3 feet higher.

Dolores River at Dolores, Colorado.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.20	2.65	4.05	3.75	2.70	2.50	2.70	3.00	2.80
2	3.10	2.85	4.30	3.60	2.65	2.40	2.70	3.00	2.80
3	3.00	3.20	4.40	3.45	2.60	2.40	2.60	3.00	2.95
4	2.90	3.25	4.35	3.40	2.60	2.50	2.60	2.90	2.95
5	2.80	3.40	4.05	3.30	2.70	2.60	2.60	2.90	3.20
6	2.75	3.45	4.30	3.20	2.75	2.50	2.60	2.90	3.40
7	2.60	3.70	4.00	3.20	2.85	2.50	2.50	2.85	3.70
8	2.50	3.75	4.05	3.20	2.90	2.40	2.70	2.80	3.35
9	2.55	3.80	4.10	3.10	3.00	2.40	2.70	2.80	2.90
10	2.60	3.50	4.10	3.10	3.00	2.35	2.80	2.80	2.90
11	2.65	3.50	3.60	3.10	3.15	2.30	3.10	2.80	2.90
12	2.65	3.45	3.80	3.00	3.00	2.30	2.90	2.80	3.00
13	2.70	3.45	3.65	3.00	2.95	2.30	2.75	2.85	3.00
14	2.70	3.35	3.40	2.95	3.00	2.30	2.75	2.90	2.90
15	2.75	3.60	3.20	2.90	3.10	2.25	2.75	2.90	2.75
16	2.70	3.55	3.15	2.90	3.50	2.20	2.70	2.80	2.75
17	2.75	3.65	3.25	2.90	3.05	2.35	2.70	2.80	2.55
18	2.60	3.30	3.30	3.00	3.00	2.45	2.70	2.80	2.65
19	2.60	3.45	3.25	2.90	3.05	2.55	2.70	2.80	2.80
20	2.70	3.45	3.75	2.90	3.00	2.55	2.80	2.80	2.75
21	2.70	3.40	3.80	2.80	2.85	2.60	2.80	2.80	2.75
22	2.85	3.95	3.90	2.80	2.80	2.60	2.65	2.85	2.70
23	2.90	4.05	4.00	2.80	2.85	2.60	4.17	2.80	2.70
24	3.10	4.25	4.10	2.70	2.80	2.60	4.05	2.80	2.70
25	3.40	4.35	4.20	2.70	2.75	2.53	4.40	2.80	2.80
26	3.45	4.50	4.25	2.60	2.70	2.50	3.20	2.80	3.20
27	3.25	4.40	4.15	2.60	2.65	2.50	3.10	2.80	3.20
28	3.20	4.30	4.30	2.65	2.60	2.85	3.10	2.90	3.20
29	3.10	3.95	4.25	2.70	2.60	3.00	3.10	2.80	3.20
30	3.05	3.90	4.10	2.70	2.60	2.85	3.00	2.80	3.20
31	3.05	.....	3.90	.....	2.60	2.80	.....	2.80	.....

Fall Creek at Seymour, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.00	4.20	3.00	2.70	2.65	3.00	2.60
2	.....	4.00	4.15	3.00	2.60	2.60	3.00	2.50
3	.....	3.95	4.15	2.95	2.60	2.60	2.95	2.55
4	.....	3.90	4.15	2.90	2.60	2.65	2.90	2.55
5	.....	3.95	4.15	2.90	2.60	2.60	2.85	2.55
6	.....	4.05	4.05	2.90	2.60	2.60	2.80	2.55
7	.....	4.05	4.00	2.90	2.60	2.60	2.80	2.25
8	.....	4.15	4.10	2.90	2.60	2.60	2.80	2.40
9	.....	4.20	4.10	3.20	2.60	2.60	2.80	2.60
10	.....	4.05	3.95	3.60	2.60	2.95	2.75	2.50
11	.....	4.00	3.85	3.55	2.60	3.00	2.70	2.50
12	3.10	3.80	3.80	3.50	2.60	2.90	2.70	2.50
13	3.15	3.80	3.85	3.45	2.60	2.80	2.70	2.55
14	3.15	3.70	3.90	3.20	2.60	2.80	2.70	2.45
15	3.05	3.70	3.40	3.00	2.60	2.70	2.70	2.65
16	3.10	3.75	3.40	3.00	2.60	2.70	2.70	2.55
17	3.05	3.75	3.45	3.20	2.50	2.70	2.70	2.45
18	3.05	3.60	3.40	3.30	2.60	2.70	2.70	2.50
19	3.05	3.55	3.35	3.30	2.60	2.75	2.60	2.50
20	3.10	3.55	3.30	3.15	2.60	2.85	2.60	2.45
21	3.15	3.80	3.10	3.00	2.60	2.80	2.60	2.50
22	3.30	3.95	3.10	2.90	2.60	2.80	2.65	2.60
23	3.55	4.35	3.05	2.90	2.55	4.45	2.65	2.60
24	3.80	4.35	3.00	2.90	2.55	4.05	2.60	2.60
25	4.00	4.60	3.00	2.85	2.55	4.75	2.60	2.60
26	4.05	4.90	3.00	2.80	2.60	3.50	2.60	2.65
27	4.00	4.95	3.00	2.80	2.55	3.35	2.60	2.30
28	4.00	4.85	3.00	2.80	2.90	3.25	2.60	2.60
29	3.90	4.75	3.00	2.80	2.85	3.10	2.60	2.90
30	3.85	4.70	3.00	2.80	2.75	3.10	2.85	3.05
31	.....	4.40	.....	2.80	2.70	.....	2.50	.....

Uncompahgre River at Uncompahgre, Colorado.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.00	5.00	3.40	3.00	3.08	3.35	3.13
2	4.00	4.80	3.20	2.85	3.10	3.43	3.13
3	3.90	4.20	3.20	2.80	3.18	3.35	3.13
4	4.10	4.40	3.20	2.80	3.10	3.30	3.03
5	4.20	4.30	3.20	2.90	3.10	3.23	3.03
6	4.40	4.25	3.20	2.90	3.10	3.20	3.03
7	4.50	4.25	3.20	2.90	3.05	3.23	3.00
8	4.40	4.45	3.50	2.90	3.00	3.25	3.13
9	4.30	4.40	3.35	2.85	3.13	3.23	3.13
10	4.45	4.30	3.20	2.75	3.13	3.23	3.10
11	4.05	4.10	3.20	2.75	3.48	3.23	3.03
12	4.05	4.15	3.35	2.70	3.35	3.23	3.00
13	3.95	4.10	3.35	2.70	3.23	3.18	3.03
14	3.60	4.15	3.45	2.70	3.20	3.18	3.03
15	3.50	4.00	3.50	2.70	3.23	3.18	3.18
16	3.85	3.85	3.30	2.70	3.18	3.13	3.08
17	3.85	3.85	3.35	2.70	3.10	3.10	3.18
18	3.85	3.90	3.35	2.70	3.15	3.10	3.20
19	4.30	3.75	3.35	2.70	3.18	3.13	3.20
20	4.40	3.80	3.45	2.80	3.23	3.08	3.15
21	5.05	3.75	3.45	2.75	3.25	3.10	3.15
22	5.15	3.70	3.30	2.85	3.40	3.08	3.20
23	5.15	3.50	3.20	3.05	3.90	3.08	3.20
24	5.25	3.75	3.00	3.05	3.98	3.05	3.13
25	5.00	3.75	3.05	3.08	3.65	3.03	3.13
26	5.05	3.60	3.05	3.08	3.58	3.03	3.10
27	5.45	3.50	3.00	3.00	3.48	3.08	3.10
28	5.05	3.60	3.00	3.08	3.45	3.10	3.00
29	4.90	3.50	3.00	3.15	3.43	3.10	3.00
30	4.50	3.45	3.00	3.10	3.40	3.13	3.00
31	4.60	.....	3.00	3.18	.....	3.18	.....

Black's Fork River at Granger, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.20	10.30	3.20	2.40	2.00	1.80	.....	.....
2	.....	3.50	9.40	3.10	2.40	2.60	1.80	.....	.....
3	.....	.....	8.00	3.00	2.40	3.00	1.80	.....	.....
4	.....	3.40	7.70	2.90	2.40	2.20	.....	.....	.....
5	.....	3.40	7.60	2.80	2.30	1.90	1.70	.....	2.90
6	.....	4.00	7.30	2.70	2.30	.....	1.70	.....	.....
7	.....	5.10	.....	2.60	2.20	1.80	1.70	1.92	.....
8	.....	5.00	6.30	2.60	2.00	1.70	1.70	.....	.....
9	.....	5.30	6.70	2.60	.....	1.70	1.70	.....	.....
10	.....	.....	7.10	2.50	1.80	1.70	1.60	.....	.....
11	.....	4.90	7.40	2.40	1.70	1.70	.....	.....	.....
12	.....	4.70	7.10	.....	1.70	1.70	1.70	.....	2.90
13	.....	4.30	6.50	2.40	1.60	.....	1.70	.....	.....
14	.....	3.80	.....	2.70	1.50	1.60	1.70	1.90	.....
15	.....	3.60	6.50	3.30	1.50	1.60	1.70	.....	.....
16	.....	3.50	6.00	3.10	.....	1.60	.....	2.40	.....
17	.....	.....	5.80	2.90	3.30	1.60	.....	2.60	.....
18	3.00	3.30	5.50	3.30	4.90	1.60	.....	2.80	.....
19	2.60	3.30	5.30	.....	5.20	1.50	.....	2.90	2.90
20	2.90	3.30	5.20	3.00	4.10	.....	.....	2.90	.....
21	3.30	3.30	4.90	2.80	5.25	1.60	.....	2.90	.....
22	3.30	3.60	4.60	2.60	4.40	1.90	.....	.....	.....
23	3.40	4.00	4.40	3.70	.....	1.90	.....	2.90	.....
24	3.20	4.60	4.20	2.90	3.90	1.90	1.80	2.90	.....
25	3.20	6.00	4.00	2.90	2.50	2.00	.....	2.90	.....
26	.....	6.60	3.80	.....	2.20	3.90	.....	2.90	2.90
27	3.40	7.00	3.60	2.80	2.10	.....	.....	2.80	.....
28	3.50	7.70	.....	2.80	2.00	2.00	.....	2.70	.....
29	3.50	8.00	3.50	2.70	1.90	1.90	.....	.....	.....
30	3.20	8.40	3.40	2.60	2.40	1.80	.....	.....	.....
31	.....	.....	.....	2.40	2.10	.....	1.97	.....	.....

Green River at Green River, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	1.90	4.77	4.02	2.58	1.62	1.30	1.60
2	.....	1.85	4.97	3.98	2.53	1.65	1.30	1.60
3	.....	1.87	4.85	3.88	2.43	1.60	1.25	1.60
4	.....	1.90	5.15	3.80	2.40	1.60	1.25	1.65
5	.....	1.95	5.45	3.78	2.35	1.55	1.25	1.65
6	.....	1.90	5.25	3.70	2.28	1.55	1.20	1.65
7	.....	2.00	5.25	3.63	2.20	1.50	1.20	1.65
8	.....	2.15	5.02	3.60	2.13	1.50	1.20	1.70
9	1.60	2.22	4.80	3.55	2.08	1.50	1.15	1.70
10	1.55	2.25	4.90	3.50	2.03	1.50	1.15	1.70
11	1.60	2.20	5.35	3.45	1.98	1.50	1.15	1.70
12	1.55	2.15	5.75	3.40	1.90	1.50	1.15	1.70
13	1.50	2.15	5.92	3.35	1.85	1.50	1.15	1.70
14	1.57	2.10	5.82	3.35	1.78	1.45	1.10	1.70
15	1.67	2.05	5.87	3.45	1.73	1.45	1.10	1.70
16	1.70	2.05	5.97	3.70	1.70	1.40	.....	1.70
17	1.70	2.05	5.97	3.70	1.70	1.35	.....	1.70
18	1.62	2.00	6.05	3.55	2.00	1.35	.....	1.70
19	1.55	2.00	6.05	3.50	1.83	1.27	.....	1.70
20	1.52	1.95	6.18	3.43	1.90	1.25	.....	1.70
21	1.57	1.90	6.20	3.33	2.08	1.25	.....	1.80
22	1.57	1.95	6.00	3.25	2.10	1.30	.....	1.80
23	1.55	2.02	5.70	3.08	2.15	1.25	.....	1.80
24	1.50	2.30	5.45	2.98	2.08	1.20	.....	1.80
25	1.50	2.65	5.10	2.90	1.93	1.20	.....	1.80
26	1.57	2.85	4.93	2.88	1.88	1.20	.....	1.80
27	1.67	2.90	4.73	2.80	1.78	1.20	.....	1.80
28	1.85	2.97	4.55	2.73	1.68	1.25	.....	.....
29	1.92	3.37	4.43	2.65	1.58	1.30	.....	.....
30	1.90	3.87	4.23	2.60	1.57	1.30	.....	.....
31	.....	4.27	.....	2.53	1.60	.....	.....	.....

Green River at Blake, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.55	1.80	1.80	3.60	6.35	8.85	5.95	4.40	2.95	3.10	2.55	.....
2	1.65	1.70	1.80	3.60	6.35	9.30	5.75	4.30	2.85	3.20	2.50	.....
3	1.75	1.70	1.90	3.50	6.00	9.65	5.55	3.95	2.75	3.05	2.50	.....
4	1.85	1.70	2.00	3.45	5.75	9.65	5.35	3.75	2.65	3.00	2.50	.....
5	1.70	1.60	1.95	3.40	5.55	9.45	5.15	3.65	2.50	3.00	2.40	.....
6	1.70	1.70	2.00	3.20	5.55	9.25	5.05	3.60	2.50	2.90	2.40	.....
7	1.60	1.75	2.00	3.00	5.80	9.05	5.00	3.50	2.50	2.85	2.40	.....
8	1.65	1.70	2.00	2.90	6.20	8.95	4.80	3.45	2.45	2.70	2.40	.....
9	1.70	1.70	2.05	2.90	6.55	8.75	4.70	3.35	2.40	2.70	2.35	.....
10	1.60	1.80	2.10	2.90	6.75	8.70	4.60	3.30	2.70	2.70	2.30	.....
11	1.65	1.70	2.10	3.00	6.85	8.70	4.95	3.40	2.65	2.70	2.25	.....
12	1.70	1.60	2.10	3.10	6.90	8.45	4.35	3.35	2.85	2.60	2.20	.....
13	1.60	1.60	2.10	3.20	6.75	8.25	4.20	3.15	2.80	2.60	2.20	.....
14	1.50	1.50	2.20	3.45	6.55	8.20	4.25	3.00	2.70	2.60	2.20	.....
15	1.45	1.50	2.30	3.50	6.40	8.30	4.40	2.90	2.70	2.60	2.15	.....
16	1.55	1.60	2.35	3.70	6.10	8.25	4.30	2.80	2.70	2.60	2.10	.....
17	1.65	1.70	2.40	3.75	5.70	8.15	4.70	2.65	2.80	2.60	2.20	.....
18	1.75	1.70	2.55	3.90	5.45	8.00	4.30	2.60	2.65	2.55	2.30	.....
19	1.60	1.80	2.85	3.85	5.20	7.95	4.45	2.50	2.65	2.50	2.40	.....
20	1.65	1.80	3.15	3.95	5.00	7.75	4.80	2.50	3.45	2.50	2.50	.....
21	1.70	1.90	3.10	4.10	4.85	7.70	4.95	2.65	4.45	2.50	2.40	.....
22	1.75	1.90	2.75	4.45	4.70	7.55	4.70	2.85	3.00	2.50	2.30	.....
23	1.75	1.90	2.70	4.10	4.70	7.50	4.55	3.05	5.55	2.50	2.40	.....
24	1.70	1.80	2.80	3.80	4.70	7.40	4.45	3.20	4.75	2.45	2.50	.....
25	1.60	1.80	2.85	3.60	4.85	7.35	4.40	3.15	4.00	2.40	2.60	.....
26	1.60	1.70	3.05	3.75	5.35	7.15	4.60	3.30	4.25	2.40	2.70	.....
27	1.60	1.75	3.25	4.10	5.80	6.90	4.60	3.40	3.70	2.40	2.65	.....
28	1.70	1.80	3.40	5.00	6.65	6.55	4.65	3.65	3.45	2.55	2.45	.....
29	1.70	1.80	3.55	5.70	7.45	6.35	4.60	4.15	3.35	2.40	.....	.....
30	1.80	.....	3.70	6.10	8.00	6.15	4.50	3.45	3.20	2.55	.....	1.80
31	1.80	.....	3.60	.....	8.40	.....	4.50	3.15	.....	2.65	.....	.....

San Juan River at Arboles, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	7.15	7.10	5.70	5.70	5.80	5.85	5.90
2	.....	7.20	7.00	5.70	5.65	5.70	5.85	5.90
3	.....	7.50	6.90	5.70	5.60	5.70	5.90	5.85
4	.....	7.60	6.80	5.70	5.60	6.05	5.90	5.80
5	.....	7.65	6.65	5.70	5.75	5.85	5.85	5.70
6	.....	7.75	6.60	5.85	5.75	5.70	5.80	5.60
7	.....	7.65	6.50	5.85	5.65	5.60	6.00	5.55
8	.....	7.40	6.50	5.70	5.60	5.60	5.90	5.50
9	.....	7.25	6.50	5.75	5.50	5.65	5.80	5.50
10	.....	7.35	6.40	5.75	5.50	6.35	5.95	5.65
11	.....	7.25	6.30	5.70	5.50	6.75	5.90	5.75
12	6.80	7.10	6.30	5.70	5.50	6.45	5.80	5.70
13	6.70	7.05	6.20	5.80	5.50	5.95	5.90	5.70
14	6.70	6.85	6.20	5.85	5.50	5.80	5.80	5.70
15	6.85	6.75	6.10	6.00	5.50	5.75	5.80	5.70
16	6.85	6.65	6.00	5.85	5.50	5.70	5.80	5.75
17	6.70	6.60	6.00	6.30	5.50	5.60	5.80	5.90
18	6.70	6.60	6.00	6.25	5.50	5.60	5.80	5.85
19	6.65	6.80	5.95	6.20	5.50	5.80	5.80	5.80
20	6.60	6.95	5.95	6.35	5.40	6.05	5.80	5.80
21	6.80	7.25	5.90	6.15	5.40	5.95	5.80	5.80
22	6.90	7.25	5.90	6.15	5.40	5.80	5.75	5.80
23	6.80	7.35	5.80	6.20	5.40	5.95	6.05	5.80
24	6.90	7.50	5.80	6.15	5.40	6.90	6.15	5.80
25	7.25	7.60	5.80	6.00	5.50	6.55	5.95	5.80
26	7.60	7.70	5.70	5.95	5.50	6.20	5.85	5.80
27	7.45	7.60	5.65	5.90	5.50	6.10	5.85	5.80
28	7.25	7.55	5.70	5.80	6.50	6.00	6.40	5.80
29	7.15	7.35	5.70	5.80	6.20	5.95	6.10	5.80
30	7.15	7.40	5.70	5.80	6.05	5.90	6.05	5.80
31	.....	7.40	.....	5.75	5.90	.....	5.95	.....

Piedras River at Arboles, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.65	4.05	2.70	2.60	2.80	3.20	3.00
2	.....	4.75	3.85	2.70	2.60	2.70	3.15	3.00
3	.....	4.80	3.80	2.70	2.50	2.70	3.05	3.00
4	.....	4.85	3.70	2.60	2.50	2.75	3.10	2.95
5	.....	4.90	3.60	2.60	2.60	2.80	3.05	2.85
6	.....	4.95	3.50	2.60	2.60	2.70	3.00	2.80
7	.....	4.65	3.45	2.60	2.55	2.60	3.00	2.80
8	.....	4.50	3.40	2.70	2.50	2.60	3.00	2.75
9	.....	4.30	3.30	2.70	2.50	2.60	3.00	2.70
10	.....	4.35	3.30	2.70	2.50	3.05	3.00	2.85
11	.....	4.25	3.20	2.70	2.40	3.25	3.00	2.80
12	4.00	4.10	3.20	2.70	2.40	3.00	2.90	2.75
13	3.90	4.05	3.20	2.75	2.40	2.90	3.00	2.70
14	3.90	3.85	3.10	2.85	2.40	2.80	3.00	2.70
15	4.05	3.80	3.00	2.80	2.40	2.75	3.00	2.70
16	4.05	3.70	3.00	2.70	2.40	2.70	3.00	2.75
17	3.90	3.70	3.00	2.75	2.45	2.65	3.00	2.80
18	3.85	3.85	3.00	3.00	2.50	2.60	2.90	2.80
19	3.70	3.95	2.90	3.00	2.50	2.75	2.90	2.80
20	3.55	4.10	2.90	2.95	2.40	3.65	2.90	2.80
21	3.65	4.15	2.90	2.80	2.40	3.15	2.80	2.80
22	3.85	4.30	2.80	2.85	2.40	3.00	2.80	2.80
23	3.75	4.35	2.80	2.95	2.45	4.60	2.90	2.70
24	4.00	4.40	2.80	3.05	2.50	5.35	3.05	2.80
25	4.50	4.30	2.75	3.00	2.50	4.45	3.05	2.80
26	4.75	4.45	2.70	2.85	2.50	3.95	3.00	2.80
27	4.60	4.50	2.65	2.80	2.50	3.70	3.00	2.80
28	4.45	4.35	2.70	2.70	3.15	3.55	3.10	2.80
29	4.65	4.25	2.70	2.70	3.30	3.40	3.00	2.80
30	4.65	4.30	2.70	2.70	2.80	3.30	3.00	2.80
31	.....	4.30	.....	2.65	2.90	.....	3.00	.....

Animas River at Durango, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.20	7.05	5.40	5.20	5.20	6.10	5.40	5.10
2	.....	7.50	6.85	5.40	5.20	5.15	6.00	5.40	.....
3	.....	7.65	6.85	5.30	5.20	5.50	5 95	5.40	5.20
4	.....	7.70	6.85	5.30	5.15	5.10	5.90	5.30	.....
5	.....	7.95	6.75	5.30	5.10	5.10	5.85	5.30	5.10
6	.....	8.00	6.65	5.30	5.10	5.10	5.80	5.25	5.10
7	.....	7.55	6.65	5.25	5.10	5.10	5.85	5.25	.....
8	.....	7.30	6.55	5.25	5.10	5.10	5.70	5.20	.....
9	.....	7.05	6.45	5.30	5.10	5.15	5.70	5.25	.....
10	.....	7.10	6.40	5.30	5.10	5.40	5.65	5.25	5.00
11	.....	6.90	6.25	5.45	5.05	5.90	5.60	5.30	.....
12	6.35	6.65	6.15	5.45	5.00	5.65	5.60	5.30	.....
13	6.15	6.40	6.15	5.45	5.00	5.60	5.65	5.25	5.10
14	6.25	6.40	6.10	5.50	5.00	5.55	5.70	5.25	.....
15	6.45	6.35	6.05	5.50	4.95	5.50	5.60	5.30	5.00
16	6.45	6.25	6.00	5.50	4.90	5.40	5.60	5.25	.....
17	6.40	6.25	5.95	5.55	4.90	5.40	5.60	5.30	.....
18	6.20	6.45	5.90	5.65	4.90	5.35	5.55	5.25	.....
19	6.20	6.65	5.80	5.70	4.90	5.40	5.50	5.30	5.10
20	6.15	6.95	5.80	5.55	4.90	6.35	5.50	5.30	.....
21	6.25	6.95	5.70	5.50	4.90	6.05	5.45	5.30	.....
22	6.35	7.15	5.70	5.45	4.90	5.90	5.60	5.25	5.10
23	6.55	7.30	5.65	5.50	4.90	8.40	5.50	5.20	.....
24	7.05	7.70	5.60	5.55	4.90	9.30	5.50	5.25	5.10
25	7.50	7.35	5.60	5.50	4.90	7.40	5.50	5.20	.....
26	7.90	7.80	5.55	5.40	4.80	6.90	5.40	5.20	5.20
27	7.75	7.75	5.50	5.40	4.80	6.65	5.45	5.15	.....
28	7.45	7.85	5.45	5.40	4.95	6.45	5.50	5.05	.....
29	7.20	7.65	5.50	5.35	5.25	6.20	5.50	5.10	.....
30	7.15	7.55	5.40	5.30	5.30	6.10	5.45	5.10	5.00
31	.....	7.35	.....	5.25	5.20	.....	5.40	.....	.....

Gila River at Buttes, Arizona.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	1.90	1.71	1.76	1.48	1.11	0.93	2.75	2.50	2.80	3.80	2.40
2	2.20	1.85	1.71	1.86	1.48	1.10	.90	3.70	2.38	4.70	3.65	2.38
3	2.20	1.80	1.72	1.87	1.47	1.09	.91	2.90	2.25	3.80	3.50	2.38
4	2.15	1.85	1.80	1.88	1.46	1.08	.91	4.40	2.38	5.20	3.30	2.35
5	2.10	1.85	1.79	1.90	1.44	1.07	.88	3.20	2.40	3.70	3.15	2.31
6	2.10	1.80	1.79	1.90	1.41	1.06	.86	3.60	2.25	3.80	3.05	2.30
7	2.00	1.80	1.73	1.89	1.40	1.04	.86	2.50	2.13	3.75	2.95	2.30
8	2.05	1.75	1.79	1.85	1.40	1.03	1.36	2.25	2.70	4.80	2.90	2.30
9	2.05	1.70	1.80	1.81	1.38	1.02	1.20	2.13	3.95	3.90	2.80	2.30
10	2.05	1.70	1.80	1.80	1.37	1.00	1.10	1.98	4.20	3.30	2.73	2.29
11	2.05	1.75	1.79	1.74	1.38	1.00	1.04	1.90	3.15	3.00	2.70	2.28
12	2.05	1.75	1.87	1.70	1.36	.99	1.29	2.00	2.85	3.25	2.65	2.28
13	2.00	1.70	1.88	1.70	1.34	.98	1.24	1.90	2.95	5.00	2.60	2.28
14	2.00	1.70	1.90	1.67	1.32	.97	1.20	1.74	2.95	9.35	2.60	2.27
15	2.00	1.70	1.91	1.64	1.31	.95	1.45	1.70	2.70	7.90	2.58	2.27
16	2.00	1.70	1.92	1.62	1.28	.93	4.50	1.86	2.56	6.90	2.55	2.29
17	1.95	1.70	1.91	1.62	1.27	.92	2.30	1.72	2.20	5.60	2.50	2.30
18	1.95	1.70	1.87	1.62	1.25	.91	2.10	1.85	2.23	4.80	2.50	2.30
19	1.95	1.70	1.86	1.61	1.24	.91	2.10	2.06	2.50	4.10	2.48	2.30
20	1.95	1.70	1.84	1.61	1.24	.91	3.00	2.22	3.43	3.70	2.46	2.28
21	1.95	1.70	1.81	1.60	1.23	.91	5.40	2.00	3.10	3.35	2.44	2.26
22	1.90	1.70	1.79	1.60	1.20	.91	8.10	2.50	2.80	3.30	2.42	2.24
23	1.85	1.74	1.75	1.58	1.21	.90	5.10	2.24	3.00	6.75	2.40	2.23
24	1.80	1.72	1.71	1.55	1.21	.89	9.30	2.41	2.35	5.50	2.38	2.22
25	1.80	1.72	1.71	1.53	1.20	.86	4.60	2.41	2.40	6.30	2.40	2.22
26	1.80	1.72	1.71	1.50	1.18	.90	3.00	2.20	2.25	6.50	2.46	2.23
27	1.80	1.72	1.70	1.50	1.16	1.32	2.80	2.18	2.38	5.50	2.53	2.23
28	1.80	1.72	1.70	1.51	1.15	1.10	2.50	2.10	2.32	6.60	2.50	2.23
29	1.90	1.72	1.68	1.50	1.14	.98	2.15	2.05	2.15	5.00	2.48	2.30
30	1.85	.....	1.66	1.48	1.12	.96	2.10	3.70	2.05	4.60	2.44	2.30
31	1.90	.....	1.70	.....	1.12	.94	2.00	2.90	.....	4.10	.....	2.34

Colorado River at Yuma, Arizona.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	18.25	19.00	19.08	19.42	20.00	21.83	21.25	19.83	19.83	22.08	19.42	18.92
2....	18.25	19.08	19.17	19.42	20.00	22.00	21.17	19.42	19.67	20.83	19.83	18.92
3....	18.17	19.17	19.25	19.83	21.50	22.50	21.00	19.50	19.67	20.00	19.17	19.00
4....	18.08	19.42	19.33	19.42	22.17	23.25	20.83	19.60	20.33	19.67	19.00	18.83
5....	18.00	19.25	19.42	19.42	22.42	23.50	20.67	19.60	20.67	19.33	18.83	18.83
6....	18.00	19.25	19.42	20.00	22.60	23.83	20.42	19.60	19.75	19.00	18.83	18.83
7....	18.00	19.17	19.42	20.00	22.33	23.92	20.42	19.75	19.60	19.50	18.75	18.83
8....	18.00	19.08	19.42	19.92	22.33	24.00	20.25	20.00	19.67	19.00	19.08	18.83
9....	18.00	18.92	19.42	19.83	22.25	24.08	20.25	19.92	19.42	18.67	18.92	18.92
10....	18.00	18.92	19.42	19.83	22.00	24.00	20.25	19.75	19.00	18.67	18.75	18.83
11....	18.00	18.83	19.42	19.75	22.25	23.83	20.25	19.75	18.83	18.67	18.75	18.67
12....	17.92	18.83	19.25	19.67	22.33	23.75	20.00	19.75	18.92	18.75	18.83	18.42
13....	17.92	18.83	19.17	19.75	22.42	23.42	20.00	19.50	19.33	18.67	18.75	18.08
14....	17.92	18.83	19.17	19.83	23.50	23.17	20.00	19.33	18.83	18.67	18.67	17.83
15....	18.00	18.83	19.17	19.67	22.60	22.92	20.00	19.25	18.60	18.60	18.50	17.75
16....	18.17	18.75	19.17	19.75	22.75	22.75	20.00	19.17	18.42	18.50	18.50	17.50
17....	18.17	18.67	19.17	19.75	22.75	22.75	20.00	19.00	18.42	19.00	18.50	17.42
18....	18.17	18.67	19.17	19.83	22.60	22.67	20.25	19.08	18.60	19.42	17.92	17.42
19....	18.17	18.60	19.08	20.00	22.33	22.42	20.33	19.42	18.83	18.83	18.42	17.50
20....	18.17	18.50	19.08	20.00	22.17	22.42	21.00	19.75	18.92	18.83	18.42	17.83
21....	18.00	18.50	19.08	19.92	21.92	22.17	20.33	19.00	18.60	18.75	18.42	18.00
22....	18.25	18.50	19.08	19.92	21.60	21.92	20.08	19.00	18.92	19.25	18.42	18.17
23....	18.42	18.67	19.00	19.83	21.33	21.92	20.67	19.00	19.33	20.00	18.33	18.25
24....	18.50	18.75	19.00	19.83	21.08	21.83	20.75	19.00	19.25	19.17	18.25	18.25
25....	18.50	18.75	19.00	19.83	20.83	21.67	20.67	18.75	19.50	19.67	18.33	18.33
26....	18.50	18.83	19.08	19.92	20.67	21.60	20.50	18.75	18.83	19.19	18.42	18.33
27....	18.50	18.92	19.17	20.00	20.50	21.50	20.60	19.00	18.42	19.33	18.50	18.42
28....	18.67	18.92	19.25	20.00	20.50	21.50	20.50	19.00	19.50	19.17	18.50	18.42
29....	18.75	18.92	19.33	20.00	20.75	21.33	20.50	18.75	23.17	19.33	18.83	18.50
30....	18.83	.....	19.50	19.00	20.67	21.25	20.83	18.42	24.50	19.17	18.83	18.50
31....	18.92	.....	19.50	.....	21.08	.....	20.75	18.42	.....	19.33	.....	18.50

Humboldt River at Elko, Nevada.

Day.	Jan.	Feb.	Mar.*a*	Apr.*a*	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	2.17	2.40	.....	.....	3.60	5.30	5.50	2.60	2.00	1.95	2.00	2.35
2.....	2.15	2.45	.....	.....	3.65	5.90	5.40	2.60	2.00	1.97	2.00	2.35
3.....	2.14	2.45	.....	.....	3.50	6.50	5.20	2.60	2.00	1.97	2.00	2.35
4.....	2.15	2.30	.....	.....	3.50	7.35	5.00	2.55	2.00	1.98	2.00	2.40
5.....	2.15	2.47	.....	.....	3.50	7.30	4.55	2.50	2.00	1.98	2.00	2.40
6.....	2.17	2.47	.....	.....	3.55	7.50	4.50	2.45	2.00	2.00	2.00	2.40
7.....	2.00	2.30	.....	.....	3.60	7.70	4.45	2.40	1.97	2.00	2.00	2.40
8.....	2.00	2.34	2.35	.....	3.70	7.65	4.35	2.40	1.95	2.00	2.10	2.35
9.....	2.00	2.30	.....	.....	3.75	7.55	4.20	2.30	1.95	2.00	2.20	2.30
10.....	2.00	2.47	.....	.....	3.80	7.55	4.15	2.27	1.93	2.00	2.20	2.35
11.....	2.00	2.34	.....	3.45	3.90	7.10	3.95	2.25	1.93	2.00	2.25	2.40
12.....	2.00	2.30	.....	3.45	4.15	7.20	3.90	2.25	1.93	2.00	2.25	2.45
13.....	2.00	2.35	2.50	3.50	4.20	7.40	3.90	2.25	1.93	2.05	2.30	2.45
14.....	2.00	2.30	.....	3.50	4.20	7.35	3.80	2.25	1.93	2.05	2.30	2.45
15.....	2.00	2.30	.....	3.45	4.20	7.30	3.75	2.20	1.93	2.05	2.35	2.45
16.....	2.17	2.34	.....	3.60	4.10	7.35	3.65	2.20	1.90	2.10	2.35	2.45
17.....	2.15	2.20	.....	3.80	4.00	7.45	3.60	2.20	1.90	2.10	2.35	2.50
18.....	2.10	2.20	.....	3.90	3.90	7.45	3.50	2.15	1.90	2.10	2.40	2.50
19.....	2.14	2.20	.....	3.90	3.90	7.45	3.40	2.10	1.90	2.10	2.40	2.52
20.....	2.27	2.20	.....	3.90	3.80	7.50	3.30	2.10	1.90	2.10	2.40	2.50
21.....	2.27	2.20	2.70	3.90	3.70	7.55	3.20	2.10	1.90	2.10	2.40	2.50
22.....	2.25	2.20	.....	3.95	3.60	7.40	3.10	2.10	1.90	2.10	2.40	2.45
23.....	2.20	2.25	.....	3.90	3.50	7.20	2.95	2.10	1.93	2.10	2.40	2.45
24.....	2.20	2.25	.....	3.80	3.55	7.10	2.90	2.10	1.90	2.15	2.00	2.45
25.....	2.25	2.25	3.20	3.70	3.55	6.90	2.80	2.05	1.90	2.15	2.40	2.50
26.....	2.25	2.30	.....	3.80	3.55	6.70	2.75	2.05	1.90	2.15	2.40	2.50
27.....	2.25	2.30	.....	3.70	3.60	6.40	2.75	2.05	1.90	2.15	2.40	2.50
28.....	2.24	2.30	3.50	3.75	3.70	6.10	2.70	2.05	1.90	2.15	2.40	2.45
29.....	2.35	2.30	.....	3.75	3.95	5.90	2.70	2.05	1.90	2.15	2.40	2.45
30.....	2.30	.....	.....	3.70	4.30	5.70	2.65	2.00	1.90	2.15	2.35	2.45
31.....	2.35	.....	.....	.....	4.55	.....	2.60	2.00	.....	2.15	.....	2.50

a Observations discontinued from March 1 to April 11; gage taken by flood.

Humboldt River at Battle Mountain, Nevada.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.15	2.10	0.80	0.80	1.40	1.90
2	.....	8.10	2.00	.85	.80	1.40	1.90
3	.....	8.10	1.90	.90	.80	1.45	1.90
4	.....	8.05	1.80	.90	.80	1.45	1.90
5	.....	7.50	1.75	.90	.80	1.50	1.85
6	.....	7.30	1.70	.85	.80	1.50	1.80
7	.....	7.10	1.60	.85	.80	1.50	1.80
8	.....	6.80	1.50	.85	.80	1.50	1.80
9	.....	6.40	1.45	.80	.85	1.55	1.85
10	.....	6.00	1.40	.80	.85	1.60	1.85
11	.....	5.60	1.40	.80	.85	1.70	1.90
12	.....	5.30	1.35	.80	.85	1.70	1.90
13	.....	5.00	1.30	.80	.85	1.70	1.90
14	.....	4.80	1.25	.80	.85	1.65	1.90
15	.....	4.60	1.20	.80	.90	1.65	2.00
16	.....	4.40	1.15	.80	.90	1.70	2.00
17	.....	4.20	1.15	.75	.95	1.70	2.00
18	.....	4.10	1.10	.75	.95	1.70	2.00
19	.....	4.00	1.05	.75	.95	1.70	2.00
20	.....	3.80	1.00	.75	1.00	1.70	2.05
21	.....	3.70	1.00	.75	1.10	1.75	2.05
22	.....	3.60	1.00	1.10	1.10	1.75	2.05
23	.....	3.50	.95	1.00	1.15	1.80	2.10
24	.....	3.30	.95	.90	1.15	1.80	2.10
25	.....	3.10	.90	.90	1.20	1.80	2.10
26	.....	3.00	.90	.85	1.20	1.80	2.10
27	.....	2.80	.90	.85	1.30	1.80	2.10
28	8.25	2.70	.85	.85	1.35	1.80	2.15
29	8.20	2.60	.85	.85	1.35	1.85	2.15
30	8.20	2.40	.80	.80	1.40	1.85	2.15
31	.....	2.30	.80	.....	1.40	.....	2.20

Humboldt River at Golconda, Nevada.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.65	1.50	0.50	0.30	2.65	4.00	7.40	3.00	0.70	0.30	0.95	1.60
2	.63	1.50	.50	.35	2.70	4.00	7.40	2.90	.70	.30	1.00	1.60
3	.60	1.60	.50	.40	2.70	4.30	7.30	2.80	.60	.35	1.00	1.60
4	.58	1.75	.50	.50	2.70	4.50	7.20	2.60	.60	.40	1.00	1.70
5	.50	1.70	.50	.70	2.70	4.60	7.00	2.50	.50	.40	1.10	1.70
6	.50	1.70	.50	.80	2.80	4.80	6.90	2.40	.50	.50	1.10	1.70
7	.55	1.65	.50	1.60	2.90	4.90	6.60	2.20	.45	.60	1.20	1.80
8	.53	1.70	.50	2.00	3.20	4.90	6.50	2.20	.40	.60	1.20	1.80
9	.53	1.40	.50	2.40	3.20	4.90	6.10	2.10	.40	.60	1.25	1.80
10	.58	1.60	.55	2.10	3.20	5.00	5.80	2.10	.35	.60	1.20	1.85
11	.58	1.70	.60	2.00	3.30	5.30	5.80	2.00	.35	.60	1.20	1.85
12	.55	1.70	.55	1.90	3.30	5.75	5.50	1.90	.30	.60	1.30	1.80
13	.58	1.60	.50	1.70	3.30	5.70	5.20	1.80	.30	.60	1.40	1.90
14	.53	1.50	.50	1.60	3.30	5.90	5.00	1.80	.25	.60	1.50	1.90
15	.60	1.40	.50	1.50	3.30	6.00	4.95	1.60	.25	.60	1.50	2.00
16	.60	1.40	.50	1.55	3.30	6.10	4.85	1.50	.25	.60	1.60	2.00
17	.60	1.35	.40	1.60	3.30	6.40	4.80	1.50	.25	.60	1.60	2.00
18	.65	1.37	.30	1.90	3.35	6.70	4.70	1.40	.20	.60	1.60	2.10
19	.70	1.37	.20	1.70	3.40	6.70	4.50	1.35	.20	.70	1.60	2.10
20	.78	1.25	.20	1.70	3.45	6.80	4.30	1.30	.20	.70	1.60	2.15
21	.85	1.20	.20	2.10	3.40	6.90	4.00	1.20	.20	.70	1.60	2.20
22	.85	1.15	.20	2.00	3.45	6.90	3.90	1.05	.20	.70	1.60	2.20
23	1.05	1.00	.20	2.00	3.50	7.00	3.90	1.00	.20	.70	1.70	2.20
24	1.70	1.00	.20	2.20	3.50	7.00	3.60	1.00	.30	.70	1.70	2.20
25	1.10	.90	.40	2.30	3.50	7.10	3.50	1.00	.30	.75	1.70	2.20
26	1.00	.80	.75	2.30	3.50	7.10	3.50	.90	.30	.80	1.70	2.20
27	1.30	.85	.75	2.40	3.50	7.20	3.40	.80	.30	.80	1.60	2.00
28	1.35	.75	.50	2.50	3.50	7.20	3.40	.80	.30	.80	1.50	2.10
29	1.40	.60	.35	2.60	3.70	7.30	3.40	.75	.30	.90	1.50	2.15
30	1.50	.....	.35	2.60	3.80	7.40	3.10	.70	.30	.90	1.55	2.20
31	1.50	.....	.30	.....	3.90	.....	3.00	.70	.....	.90	.....	2.20

Humboldt River at Oreana, Nevada.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.72	2.80	2.40	2.04	3.80	7.10	4.70	3.20	2.45	.....	.....
2	.....	2.72	2.80	2.40	2.04	3.70	7.10	4.70	3.20	2.40	.....	.....
3	.....	2.72	2.70	2.40	2.04	3.60	7.20	4.60	3.20	2.40	.....	.....
4	.....	2.73	2.70	2.30	2.04	3.50	7.30	4.45	3.10	2.30	.....	.....
5	.....	2.73	2.50	2.30	2.04	3.40	7.40	4.40	3.10	2.20	.....	.....
6	.....	2.78	2.70	2.30	2.04	3.30	7.50	4.30	3.10	2.15	.....	3.20
7	.....	2.80	2.70	2.30	2.04	3.35	7.50	4.20	3.00	2.10	2.40	.....
8	.....	2.80	2.60	2.20	2.04	3.50	7.50	4.15	2.90	2.10	.....	.....
9	.....	2.80	2.60	2.05	2.04	3.50	7.60	4.10	2.80	2.05	.....	.....
10	.....	2.80	2.60	2.05	2.05	4.20	7.65	4.10	2.70	2.05	.....	.....
11	.....	2.80	2.60	2.05	2.05	4.50	7.60	4.00	2.70	2.05	.....	.....
12	.....	2.80	2.60	2.04	2.06	4.60	7.50	4.00	2.70	2.05	.....	2.70
13	.....	2.80	2.60	2.04	2.06	4.70	7.30	3.90	2.70	2.05	.....	.....
14	.....	2.81	2.60	2.04	2.07	4.80	7.10	3.80	2.65	2.00	.....	.....
15	.....	2.85	2.50	2.04	2.08	4.80	6.90	3.80	2.65	2.00	.....	.....
16	.....	2.81	2.50	2.04	2.09	4.90	6.70	3.70	2.65	2.00	.....	.....
17	.....	2.81	2.50	2.03	2.10	5.10	6.60	3.60	2.60	1.95	.....	.....
18	.....	2.82	2.50	2.03	2.10	5.20	6.40	3.60	2.60	1.95	.....	.....
19	.....	2.83	2.50	2.03	2.10	5.40	6.30	3.50	2.60	1.90	.....	2.80
20	.....	2.84	2.50	2.03	2.80	5.70	6.10	3.40	2.55	1.90	.....	.....
21	.....	2.84	2.50	2.03	3.20	5.70	6.00	3.50	2.55	2.20	.....	.....
22	.....	2.85	2.50	2.03	3.40	5.90	5.80	3.40	3.10	2.25	.....	.....
23	.....	2.83	2.50	2.03	3.70	6.10	5.70	3.30	3.00	2.25	.....	.....
24	.....	2.82	2.60	2.03	4.90	6.20	5.60	3.30	2.90	2.20	.....	.....
25	.....	2.81	2.60	2.03	4.80	6.30	5.40	3.20	2.60	2.20	.....	.....
26	.....	2.81	2.60	2.03	4.60	6.50	5.30	3.10	2.60	2.60	.....	2.80
27	2.70	2.81	2.65	2.04	4.50	6.50	5.20	3.00	2.55	2.50	.....	.....
28	2.70	2.81	2.65	2.04	4.25	6.60	5.10	3.10	2.55	2.40	.....	.....
29	2.70	2.80	2.55	2.04	4.05	6.80	5.10	3.20	2.50	2.40	.....	.....
30	2.71	.....	2.40	2.04	3.95	6.90	5.00	3.20	2.50	2.40	.....	.....
31	2.72	.....	2.40	.....	3.95	.....	4.90	3.20	.....	2.40	.....	.....

Rock Creek at Battle Mountain, Nevada.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	1.90	3.97	2.70	5.90	2.78	1.80
2	.....	1.70	3.50	2.75	5.70	2.70	.....
3	.....	1.77	3.35	2.85	5.50	2.68	.....
4	.....	1.80	3.27	2.85	5.15	2.65	.....
5	.....	1.75	3.22	2.95	4.95	2.63	.....
6	.....	2.05	2.80	3.05	4.65	2.60	.....
7	.....	1.92	2.60	3.10	4.40	2.58	.....
8	.....	1.90	2.55	3.10	4.10	2.55	.....
9	.....	2.05	2.55	3.15	3.85	2.50	.....
10	.....	2.02	2.50	3.20	3.75	2.50	.....
11	.....	2.05	2.40	3.35	3.50	2.50	.....
12	1.85	2.00	2.30	3.50	3.25	2.45	.....
13	1.80	2.02	2.35	3.65	3.10	2.40	.....
14	1.80	2.14	2.57	3.85	3.08	2.40	.....
15	1.85	2.15	2.82	4.10	3.05	2.35	.....
16	1.80	1.97	2.55	4.20	3.00	2.35	.....
17	1.75	2.10	2.50	4.35	3.00	2.30	.....
18	1.75	2.35	2.47	4.60	2.95	2.25	.....
19	1.80	2.55	2.55	4.95	2.93	2.20	.....
20	1.77	2.80	2.50	5.10	2.86	2.15	.....
21	1.80	3.65	2.50	5.15	2.88	2.10	.....
22	1.80	3.32	2.50	5.20	2.88	2.00	.....
23	1.80	3.37	2.57	5.25	2.85	2.00	.....
24	1.75	3.45	2.50	5.55	2.83	1.95	.....
25	1.85	3.65	2.50	5.80	2.83	1.90	.....
26	1.80	3.85	2.70	5.88	2.80	1.90	.....
27	1.87	4.40	2.65	5.95	2.78	1.85	.....
28	1.92	5.20	2.60	6.00	2.75	1.85	.....
29	1.92	4.60	2.60	6.00	2.75	1.80	.....
30	.....	4.25	2.68	6.10	2.75	1.80	.....
31	.....	4.00	.....	6.15	.....	1.80	.....

South Fork of Humboldt River at Masons Ranch, Nevada.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	0.95	1.10	1.10	17	.....	0.80	1.00	1.15	1.40
2	.....	.95	.95	1.10	1.10	18	.....	.80	1.00	1.20	1.30
3	.....	.90	.95	1.10	1.15	19	.....	.80	1.00	1.20	1.30
4	.....	.90	.95	1.10	1.15	20	.....	.80	1.00	1.20	1.30
5	.....	.90	.95	1.10	1.20	21	.....	.80	1.00	1.20	1.20
6	.....	.90	.95	1.10	1.20	22	.....	.90	1.00	1.20	1.20
7	.....	.90	.95	1.10	1.30	23	.....	.90	1.00	1.15	1.20
8	.....	.90	.95	1.10	1.30	24	.....	.95	1.00	1.15	1.10
9	.....	.85	.95	1.10	1.40	25	.....	.95	1.00	1.10	1.10
10	.....	.85	.95	1.10	1.40	26	.....	.95	1.00	1.10	1.00
11	.....	.85	.95	1.15	1.50	27	.....	.95	1.00	1.00	1.00
12	.....	.85	.95	1.15	1.60	28	.....	.95	1.00	1.00	1.00
13	.....	.85	.95	1.15	1.60	29	.....	.95	1.05	1.00	1.00
14	.....	.85	.95	1.15	1.50	30	1.00	.95	1.05	1.00	1.00
15	.....	.85	.95	1.15	1.50	31	1.00	.....	1.05	.....	1.00
16	.....	.80	.95	1.15	1.40						

Bear River at Soda Springs, Idaho.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	5.90	.....	.....	17	.....	8.20	5.90	5.30	.....	.....
2	.....	7.58	.....	.....	5.40	5.35	18	.....	.....	.....	.....	5.30	.....
3	.....	.....	.....	5.85	.....	.....	19	.....	8.00	.....	5.40	.....	.....
4	.....	.....	.....	5.80	5.35	.....	20	.....	7.90	5.85	.....	.....	.....
5	.....	7.70	7.40	.....	5.30	.....	21	.....	.....	.....	5.40	5.30	.....
6	.....	.....	7.30	5.70	.....	.....	22	.....	7.80	5.80	5.40	.....	.....
7	.....	7.93	7.00	5.65	5.30	.....	23	.....	.....	.....	.....	5.35	.....
8	.....	.....	6.90	.....	.....	.....	24	.....	7.70	5.80	5.45	.....	.....
9	.....	8.40	6.60	.....	5.30	.....	25	6.50	.....	.....	.....	5.40	.....
10	.....	8.32	6.30	5.60	.....	.....	26	6.52	7.60	.....	5.40	.....	.....
11	.....	.....	6.00	.....	5.30	.....	27	.....	.....	5.80	.....	.....	.....
12	.....	.....	.....	5.50	.....	.....	28	.....	.....	.....	5.40	5.35	.....
13	.....	8.30	6.00	.....	.....	.....	29	.....	.....	5.80	5.40	.....	.....
14	.....	.....	6.00	5.50	5.30	.....	30	7.10	.....	.....	.....	5.35	.....
15	.....	8.40	5.90	5.40	.....	.....	31	.....	.....	5.95	5.40	.....	.....
16	.....	.....	.....	.....	5.30	.....							

Bear River at Battle Creek, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.40	1.30	1.40	2.30	2.70	4.45	3.60	2.10	1.60	1.60	1.70	2.60
2	1.40	1.30	1.40	2.40	2.80	4.65	3.45	2.10	1.60	1.60	1.70	1.90
3	1.40	1.30	1.40	2.50	2.80	4.70	3.25	2.00	1.60	1.60	1.70	1.90
4	1.40	1.30	1.40	2.60	2.80	4.70	3.10	2.00	1.60	1.60	1.80	1.90
5	1.40	1.30	1.40	2.60	2.80	4.80	2.95	2.00	1.60	1.60	1.80	1.90
6	1.40	1.30	1.40	2.70	2.90	4.90	2.80	1.90	1.60	1.60	1.80	.....
7	1.40	1.30	1.40	2.80	2.90	4.80	2.70	1.90	1.60	1.60	1.80	.....
8	1.40	1.30	1.40	2.80	3.00	5.05	2.70	1.80	1.60	1.60	1.80	.....
9	1.40	1.30	1.40	2.80	3.00	5.15	2.60	1.80	1.60	1.60	1.80	.....
10	1.40	1.30	1.40	2.70	3.00	5.45	2.60	1.80	1.60	1.60	1.80	.....
11	1.40	1.30	1.40	2.70	3.00	5.60	2.50	1.80	1.60	1.60	1.70	.....
12	1.40	1.30	1.40	2.70	3.00	5.50	2.50	1.80	1.60	1.60	1.70	.....
13	1.40	1.40	1.40	2.70	3.00	5.35	2.40	1.70	1.60	1.60	1.70	.....
14	1.40	1.40	1.40	2.70	3.00	5.20	2.40	1.70	1.60	1.60	1.70	.....
15	1.40	1.40	1.40	2.70	3.00	5.10	2.40	1.70	1.60	1.60	1.70	.....
16	1.40	1.40	1.40	2.70	3.00	5.00	2.30	1.70	1.60	1.60	1.70	1.80
17	1.40	1.40	1.40	2.70	3.00	5.00	2.30	1.70	1.60	1.60	1.80	.....
18	1.40	1.40	1.40	2.70	2.90	4.90	2.20	1.70	1.60	1.60	1.80	.....
19	1.40	1.40	1.50	2.70	2.90	4.80	2.20	1.70	1.60	1.60	1.80	.....
20	1.40	1.40	1.50	2.70	2.80	4.80	2.20	1.70	1.60	1.60	1.90	.....
21	1.40	1.40	1.50	2.70	2.80	4.70	2.20	1.70	1.60	1.60	1.90	.....
22	1.40	1.40	1.60	2.60	2.70	4.60	2.10	1.70	1.60	1.60	1.90	.....
23	1.40	1.40	1.70	2.60	2.70	4.50	2.10	1.70	1.60	1.60	1.90	1.80
24	1.40	1.40	1.70	2.60	2.80	4.50	2.10	1.70	1.60	1.60	1.90	.....
25	1.40	1.40	1.80	2.60	2.90	4.40	2.10	1.70	1.60	1.60	1.90	.....
26	1.40	1.40	1.90	2.60	3.05	4.30	2.10	1.70	1.60	1.60	2.60	.....
27	1.40	1.40	2.00	2.60	3.25	4.20	2.10	1.70	1.60	1.70	2.60	.....
28	1.40	1.40	2.10	2.70	3.50	4.05	2.10	1.70	1.60	1.70	2.60	.....
29	1.40	1.40	2.10	2.70	3.60	3.85	2.10	1.70	1.60	1.70	2.60	.....
30	1.30	.....	2.20	2.70	4.05	3.70	2.10	1.60	1.60	1.70	2.60	.....
31	1.30	.....	2.30	.....	4.25	.....	2.10	1.60	.....	1.70	.....	.....

Bear River at Collinston, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	1.80	1.70	3.20	3.60	5.60	4.15	2.30	1.80	2.00	2.00	.....
2	1.90	1.80	1.70	3.30	3.60	5.90	3.95	2.30	1.80	1.95	2.00	2.30
3	1.90	1.80	1.70	3.10	3.75	5.90	3.75	2.30	1.80	1.95	2.00	.....
4	1.95	1.70	1.70	3.00	3.75	6.05	3.55	2.30	1.80	1.95	2.00	2.20
5	1.90	1.70	1.70	3.00	3.85	6.15	3.40	2.30	1.80	1.95	2.05	.....
6	1.90	1.70	1.70	3.10	3.95	6.30	3.20	2.20	1.80	1.90	2.05	.....
7	1.90	1.70	1.70	3.10	4.00	6.30	3.10	2.20	1.75	1.90	2.05	.....
8	1.90	1.70	1.70	3.20	4.00	6.20	3.00	2.20	1.75	1.90	2.05	.....
9	1.90	1.70	1.70	3.30	4.10	6.30	2.90	2.10	1.80	1.90	2.05	.....
10	1.90	1.70	1.70	3.30	4.10	6.40	2.80	2.00	1.80	1.90	2.10	.....
11	1.90	1.70	1.70	3.30	4.00	6.40	2.70	2.00	1.80	1.90	2.15	.....
12	1.90	1.70	1.70	3.40	3.95	6.40	2.70	1.95	1.80	1.90	2.20	.....
13	1.90	1.70	1.70	3.40	3.80	6.40	2.60	1.90	1.85	1.90	2.10	.....
14	2.00	1.70	1.70	3.50	3.75	6.55	2.55	1.85	1.90	1.90	2.00	.....
15	2.00	1.70	1.70	3.50	3.60	6.55	2.50	1.80	1.90	1.90	2.00	2.20
16	2.00	1.70	1.70	3.50	3.60	6.30	2.50	1.80	1.85	1.90	2.00	.....
17	2.10	1.70	1.70	3.50	3.60	6.00	2.50	1.75	1.85	1.90	2.05	.....
18	2.10	1.70	1.70	3.60	3.50	5.90	2.50	1.70	1.85	1.90	2.10	2.00
19	2.20	1.70	1.70	3.35	3.50	5.80	2.50	1.70	1.80	1.90	2.10	.....
20	2.30	1.70	1.70	3.25	3.40	5.70	2.40	1.75	1.80	1.90	2.10	.....
21	2.30	1.70	1.70	3.15	3.40	5.60	2.30	1.80	1.80	1.90	2.10	.....
22	2.20	1.70	1.70	3.10	3.40	5.50	2.20	1.90	1.85	1.90	2.15	.....
23	2.10	1.70	1.90	3.10	3.40	5.40	2.20	1.90	1.90	1.90	2.20	.....
24	2.00	1.70	2.00	3.20	3.65	5.35	2.10	1.85	1.90	1.90	2.25	.....
25	2.00	1.70	2.10	3.20	3.90	5.20	2.20	1.80	1.90	1.90	2.30	.....
26	1.70	1.70	2.20	3.10	4.10	5.10	2.25	1.85	1.95	1.90	2.30	.....
27	1.70	1.70	2.30	3.30	4.45	4.80	2.30	1.85	1.95	1.90	2.30	.....
28	1.70	1.70	2.40	3.40	4.65	4.80	2.25	1.90	1.95	2.00	2.30	2.20
29	1.70	1.70	2.70	3.40	4.85	4.60	2.20	1.90	2.00	2.00	.....	.....
30	1.70	.....	2.90	3.50	4.95	4.40	2.20	1.85	2.00	2.00	2.30	2.20
31	1.70	.....	3.00	.....	5.20	.....	2.20	1.80	.....	2.00	.....	.....

Logan River at Logan, Utah.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.60	3.85	3.10	2.80	2.70	2.65	2.60
2	.....	3.80	3.10	2.80	2.70	2.60	2.55
3	.....	3.75	3.10	2.80	2.70	2.60	2.55
4	4.70	3.70	3.10	2.80	2.70	2.60	2.55
5	.....	3.75	3.05	2.80	2.70	2.60	2.55
6	4.90	3.75	3.05	2.75	2.70	2.60	2.55
7	.....	3.70	3.05	2.75	2.70	2.55	2.50
8	.....	3.65	3.00	2.80	2.70	2.60	2.55
9	4.70	3.60	2.95	2.75	2.70	2.70	.....
10	4.70	3.55	2.95	2.75	2.65	2.65	2.55
11	.....	3.55	2.95	2.75	2.65	2.60	.....
12	4.65	3.50	2.95	2.75	2.65	2.60	.....
13	4.60	3.55	2.95	2.75	2.65	2.60	.....
14	4.60	3.50	2.90	2.75	2.65	2.60	.....
15	4.60	3.45	2.90	2.75	2.65	2.55	.....
16	4.65	3.45	2.90	2.75	2.65	2.55	.....
17	4.65	3.40	2.90	2.75	2.65	2.55	.....
18	4.65	3.40	2.90	2.70	2.65	2.55	.....
19	4.55	3.35	2.90	2.75	2.65	2.55	2.45
20	4.55	3.30	3.00	2.75	2.65	2.55	.....
21	4.45	3.30	3.00	2.75	2.65	2.55	.....
22	4.40	3.25	3.00	2.75	2.65	2.55	.....
23	4.30	3.25	2.95	2.75	2.65	2.55	.....
24	4.25	3.25	2.90	2.75	2.65	2.55	.....
25	4.15	3.20	2.90	2.75	2.65	2.55	2.45
26	4.10	3.20	2.85	2.75	2.65	2.55	.....
27	4.05	3.15	2.85	2.75	2.65	2.55	.....
28	4.00	3.15	2.85	2.70	2.65	2.40	.....
29	3.90	3.15	2.85	2.70	2.60	2.55	.....
30	3.85	3.15	2.85	2.70	2.60	2.55	.....
31	.....	3.10	2.85	.....	2.60	.....	.....

Ogden River at Eden, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.48	1.67	1.70	3.11	5.50	10.30	2.35	1.85	1.61	1.61	1.62	.....
2	1.49	1.67	1.70	.....	5.90	10.20	2.25	1.80	1.60	1.60	1.63	.....
3	1.54	1.64	1.68	3.15	5.90	10.20	2.20	1.80	1.60	1.60	1.63	1.60
4	1.54	1.62	.....	.....	6.20	9.70	2.20	1.80	1.60	1.60	1.63	.....
5	1.52	1.62	1.65	.....	7.00	8.90	2.19	1.79	1.60	1.60	1.63	.....
6	1.50	1 62	.....	3.60	7.50	8.60	2.13	1.75	1.61	1.60	1.63	.....
7	1.40	1.63	.....	.....	6.80	8.00	2.15	1.73	1.61	1.60	1.63	.....
8	1.43	1.67	1.65	4.00	6.40	7.50	2.00	1.70	1.62	1.60	1.63	.....
9	1.45	1.70	.....	.....	6.70	6.90	1.90	1.69	1.64	1.60	2.45	.....
10	1.44	1.70	.....	.....	6.30	6.70	1.93	1.65	1.64	1.60	2.00	1.60
11	1.45	1.70	1.66	.....	5.80	6.00	1.90	1.63	1.65	1.60	1.83	.....
12	1.45	1.69	.....	3.80	6.20	5.50	1.89	1.63	1.65	1.60	1.80	.....
13	1.45	1.69	.....	.....	5.65	5.20	1.95	1.62	1.65	1.60	1.78	.....
14	1.45	1.67	1.65	3.50	5.45	4.90	2.00	1.60	1.65	1.60	1.77	.....
15	1.46	1.64	.....	.....	5.20	4.70	2.10	1.60	1.64	1.60	1.70	.....
16	1.48	1.63	.....	.....	4.80	4.40	2.00	1.60	1.64	1.60	1.71	1.65
17	1.54	1.61	1.67	5.30	4.85	4.10	2.00	1.60	1.63	1.60	1.73	.....
18	1.60	1.61	.....	5.20	4.65	4.00	1.95	1.60	1.60	1.60	1.77	.....
19	1.71	1.61	.....	4.80	4.60	3.80	1.90	1.57	1.60	1.60	1.76	.....
20	1.69	1.62	.....	4.50	4.50	3.50	1.85	1.64	1.60	1.60	1.75	.....
21	1.80	1.62	1.85	4.35	4.70	3.25	1.85	1.61	1.60	1.60	1.75	.....
22	2.00	1.62	.....	4.50	5.60	3.15	1.85	1.63	1.61	1.60	....	.....
23	1.85	1.63	.....	4.40	7.30	2.90	1.85	1.63	1.63	1.60	.....	.....
24	1.80	1.63	2.80	4.50	8.60	2.70	1.85	1.63	1.62	1.60	.....	1.60
25	1.73	1.64	.....	5.20	8.50	2.55	1.85	1.63	1.61	1.60	.....	.....
26	1.73	1.64	4.50	6.20	9.20	2.55	1.85	1.62	1.61	1.60	.....	.....
27	1.71	1.65	7.50	6.50	10.00	2.88	1.80	1.62	1.60	1.61	.....	.....
28	1.70	1.70	5.70	5.60	10.50	2.48	1.78	1.61	1.60	1.62	.....	.....
29	1.68	1.70	.....	5.40	10.50	2.38	1.75	1.62	1.61	1.62	1.50	.....
30	1.68	.....	4.15	6.10	11.20	2.30	1.80	1.62	1.61	1.62	1.50	.....
31	1.67	.....	.....	.....	11.00	.....	1.90	1.61	.....	1.62	.....	2.60

Weber River at Uinta, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.70	1.70	2.10	3.40	8.75	2.00	1.86	1.30	1.40	1.60	.....
2	1.70	1.70	1.70	2.25	3.30	8.50	1.93	1.90	1.30	1.40	1.70	.....
3	1.70	1.70	1.70	2.35	3.35	7.80	1.85	1.90	1.30	1.40	1.80	.....
4	1.70	1.70	1.70	2.45	3.55	7.30	1.78	1.80	1.30	1.40	1.80	.....
5	1.70	1.70	1.70	2.55	3.90	7.05	1.71	1.70	1.30	1.40	1.80	1.70
6	1.70	1.70	1.70	2.65	4.55	6.70	1.71	1.60	1.30	1.40	1.80	.....
7	1.70	1.70	1.70	2.85	4.45	5.75	1.71	1.60	1.30	1.40	1.80	.....
8	1.70	1.70	1.70	2.95	4.40	5.95	1.71	1.50	1.30	1.40	1.90	1.70
9	1.70	1.70	1.70	3.00	4.30	6.25	1.64	1.40	1.30	1.40	2.00	.....
10	1.70	1.70	1.70	2.85	2.95	5.90	1.57	1.30	1.30	1.40	2.00	.....
11	1.70	1.70	1.70	2.65	2.85	5.50	1.49	1.20	1.30	1.40	2.00	.....
12	1.70	1.70	1.70	2.50	3.55	5.15	1.49	1.10	1.30	1.40	2.00	1.70
13	1.70	1.70	1.80	4.10	3.60	4.75	1.49	1.10	1.30	1.40	2.00	.....
14	1.70	1.70	1.90	4.40	3.35	4.65	1.71	1.00	1.30	1.40	2.00	1.60
15	1.70	1.70	1.90	4.40	2.95	4.40	1.64	1.00	1.30	1.40	1.90	.....
16	1.70	1.70	2.00	3.55	3.00	3.75	1.49	1.00	1.30	1.40	1.80	.....
17	1.70	1.70	2.15	3.10	2.80	3.19	1.49	1.00	1.30	1.40	1.70	.....
18	1.70	1.70	2.30	2.55	2.80	3.10	1.49	1.00	1.30	1.60	1.70	1.60
19	1.70	1.70	2.55	2.65	2.70	3.10	1.93	1.00	1.30	1.60	1.70	.....
20	1.70	1.70	2.75	2.70	2.70	3.01	2.00	1.00	1.30	1.60	1.70	.....
21	1.70	1.70	2.90	2.80	2.85	2.84	2.00	1.00	1.30	1.60	1.70	.....
22	1.70	1.70	3.10	2.85	2.90	2.66	2.00	1.00	1.30	1.60	1.70	.....
23	1.70	1.70	3.25	2.60	2.90	2.57	2.00	a1.30	1.30	1.60	1.70	.....
24	1.70	1.70	2.95	2.60	4.85	2.48	2.00	1.30	1.30	1.60	1.70	1.50
25	1.70	1.70	2.90	2.60	5.70	2.48	1.93	1.30	1.30	1.60	1.80	.....
26	1.70	1.70	2.75	2.75	6.50	2.66	1.93	1.30	1.30	1.60	1.80	.....
27	1.70	1.70	2.65	2.95	6.95	2.22	1.93	1.30	1.30	1.60	1.70	.....
28	1.70	1.70	2.55	3.15	7.95	2.22	1.86	1.30	1.40	1.60	1.70	.....
29	1.70	1.70	2.45	3.35	8.10	2.14	1.86	1.30	1.40	1.60	1.70	1.50
30	1.70	.....	2.45	3.50	8.20	2.07	1.86	1.30	1.40	1.60	1.70	.....
31	1.70	.....	2.40	.....	8.80	.....	1.86	1.30	.....	1.60	.....	.....

a New gage put in August 23.

Provo River at Provo Canyon, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
1	4.20	4.30	4.20	4.50	4.80	7.30	4.50	4.40	4.20	4.30	4.30	.....
2	4.10	4.20	4.20	4.50	4.80	7.30	4.40	4.40	4.20	4.30	4.30	.....
3	4.10	4.20	4.20	4.50	4.80	7.80	4.30	4.40	4.20	4.30	4.30	.....
4	4.10	4.20	4.20	4.50	4.90	7.60	4.30	4.30	4.20	4.30	4.30	.....
5	4.20	4.20	4.20	4.50	5.00	7.30	4.30	4.30	4.20	4.30	4.30	4.40
6	4.20	4.20	4.20	4.50	5.20	6.90	4.30	4.30	4.20	4.30	4.30	.....
7	4.20	4.20	4.20	4.50	5.40	6.90	4.30	4.20	4.20	4.30	4.30	.....
8	4.20	4.20	4.20	4.50	5.40	6.90	4.20	4.20	4.20	4.30	4.60	.....
9	4.20	4.20	4.20	4.40	5.50	6.80	4.20	4.20	4.20	4.30	4.60	.....
10	4.20	4.20	4.20	4.40	5.30	6.80	4.20	4.20	4.20	4.30	4.60	.....
11	4.20	4.20	4.20	4.30	5.30	6.60	4.20	4.20	4.20	4.30	4.60	.....
12	4.20	4.20	4.20	5.30	5.20	6.50	4.20	4.20	4.20	4.30	4.50	4.40
13	4.20	4.30	4.20	5.80	5.20	6.50	4.20	4.20	4.20	4.30	4.50	.....
14	4.20	4.30	4.20	5.90	4.90	6.20	4.20	4.20	4.20	4.30	4.50	.....
15	4.20	4.30	4.30	5.80	4.70	6.00	4.30	4.20	4.20	4.30	4.40	.....
16	4.20	4.20	4.30	5.30	4.70	5.80	4.30	4.20	4.20	4.30	4.40	.....
17	4.30	4.20	4.30	4.70	4.70	5.60	4.30	4.20	4.20	4.30	4.40	.....
18	4.30	4.20	4.40	4.70	4.70	5.00	4.30	4.20	4.20	4.30	4.40	.....
19	4.40	4.20	4.40	4.60	4.70	4.80	4.20	4.20	4.20	4.30	4.40	4.40
20	4.40	4.20	4.40	4.60	4.70	4.60	4.20	4.20	4.30	4.30	4.40	.....
21	4.50	4.20	4.50	4.60	4.70	4.60	4.30	4.20	4.30	4.30	4.40	.....
22	4.50	4.20	4.60	4.60	4.70	4.90	4.90	4.20	4.30	4.30	4.50	.....
23	4.40	4.20	4.60	4.60	4.70	4.80	4.80	4.20	4.30	4.30	4.50	.....
24	4.30	4.20	4.60	4.60	5.90	4.80	4.70	4.20	4.30	4.30	4.50	.....
25	4.30	4.20	4.70	4.60	5.60	4.70	4.50	4.20	4.30	4.30	4.50	.....
26	4.30	4.20	4.70	4.70	6.00	4.60	4.50	4.20	4.30	4.30	4.50	4.40
27	4.30	4.20	4.80	4.70	6.20	4.60	4.50	4.20	4.30	4.30	4.40	.....
28	4.30	4.20	4.90	4.70	6.50	4.60	4.50	4.20	4.30	4.30	4.40	.....
29	4.30	4.20	4.60	4.70	7.00	4.60	4.50	4.20	4.30	4.30	.....	.....
30	4.30	.....	4.60	4.80	7.80	4.50	4.50	4.20	4.30	4.30	.....	.....
31	4.30	.....	4.60	.....	8.50	.....	4.50	4.20	.....	4.30	.....	.....

Portneuf River at McCammon, Idaho.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	3.50	4.50	3.25	12	.....	3.83	4.17	3.00	23	3.46	3.50	3.58	.....
2	.....	3.50	4.50	3.08	13	.....	3.75	4.08	2.92	24	3.50	3.83	3.58	.....
3	.....	3.50	4.46	3.08	14	3.50	3.75	4.08	3.00	25	3.50	4.00	3.54	.....
4	.....	3.58	4.42	3.00	15	3.67	3.58	4.00	3.00	26	3.50	4.08	3.50	.....
5	.....	3.63	4.50	3.00	16	3.67	3.58	4.00	3.00	27	3.46	4.17	3.46	.....
6	.....	3.83	4.42	3.00	17	3.67	3.50	4.04	3.00	28	3.58	4.25	3.42	.....
7	.....	3.92	4.42	2.92	18	3.50	3.50	4.00	3.00	29	3.58	4.25	3.33	.....
8	.....	3.83	4.25	2.92	19	3.50	3.50	4.00	.....	30	3.50	4.29	3.25	.....
9	.....	3.92	4.25	2.88	20	3.50	3.54	3.92	.....	31	.....	4.50	.....	.....
10	.....	3.92	4.25	2.88	21	3.50	3.54	3.83	.....					
11	.....	3.92	4.25	2.88	22	3.46	3.50	3.83	.....					

Malad River at Taponis, Idaho.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	.....	.....	1.80	12	8.00	.....	.....	.....	23	8.60	.....	.....	.....
2	9.40	7.20	.....	.....	14	8.60	5.60	1.80	.....	24	.....	7.67	.....	.....
4	.....	.....	2.30	1.60	15	.....	.....	.....	1.80	25	.....	.....	.....	1.80
5	9.60	.....	.....	.....	16	8.80	.....	.....	.....	26	7.60	.....	.....	.....
7	.....	6.40	2.20	.....	17	.....	6.25	.....	.....	28	7.40	8.50	.....	.....
8	.....	.....	.....	1.70	18	.....	.....	2.00	1.80	29	.....	.....	.....	1.90
9	7.80	.....	.....	.....	19	9.60	.....	.....	.....	30	7.40	.....	.....	.....
10	.....	6.20	.....	.....	21	8.80	7.17	.....	.....	31	.....	9.00	.....	.....
11	.....	.....	2.00	1.70	22	.....	.....	.....	1.80					

Snake River at Montgomerys Ferry, Idaho.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.80	9.25	9.20	3.95	2.75	2.70
2	.....	3.80	9.80	8.90	3.90	2.70	2.70
3	.....	3.80	10.05	8.65	3.85	2.70	2.70
4	.....	3.80	10.25	8.50	3.70	2.70	2.70
5	3.20	4.00	10.50	8.35	3.60	2.70	2.70
6	2.95	4.10	10.75	8.15	3.50	2.70	2.70
7	2.75	4.30	11.00	7.90	3.50	2.70	2.70
8	2.70	4.85	11.00	7.65	3.40	2.70	2.70
9	2.60	5.35	10.95	7.45	3.35	2.70	2.70
10	2.65	5.40	10.65	7.20	3.25	2.65	2.70
11	2.70	5.40	10.50	6.95	3.15	2.65	2.70
12	2.80	5.40	10.70	6.75	3.10	2.70	2.70
13	2.85	5.30	11.10	6.55	3.10	2.70	2.70
14	2.90	5.20	11.45	6.50	3.10	2.70	2.70
15	3.00	5.05	11.65	6.45	3.00	2.70	2.70
16	2.90	5.00	11.75	6.55	2.90	2.70	2.70
17	3.05	4.90	11.80	6.60	2.90	2.70	2.70
18	3.20	4.85	11.85	6.50	2.80	2.70	2.70
19	3.20	4.80	11.95	6.45	2.80	2.70	2.70
20	3.15	4.70	12.10	6.25	2.80	2.70	2.70
21	2.95	4.60	12.20	6.05	2.80	2.70	2.70
22	2.85	4.50	12.25	5.75	2.80	2.70	2.70
23	2.80	4.50	12.30	5.55	2.80	2.70	2.70
24	2.80	4.90	12.10	5.35	2.80	2.70	2.70
25	2.80	5.30	11.80	5.10	2.90	2.70	.....
26	2.85	5.85	11.35	4.85	2.90	2.70	.....
27	2.90	6.45	10.90	4.75	2.80	2.70	.....
28	2.95	6.80	10.35	4.55	2.80	2.70	.....
29	3.25	7.25	9.90	4.35	2.80	2.80	.....
30	3.65	7.90	9.50	4.20	2.80	2.75	.....
31	.....	8.60	.....	4.05	2.80	.....	.....

Little Camas Creek at Little Camas Store, Idaho.

Day.	March.			April.			May.			June.			July.			August.		
	First channel, gage height.	Second channel, gage height.	Third channel, gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.
1	....	....	....	1.20	1.30	1.00	1.60	1.50	1.30	1.70	1.90	1.30	0.70	0.60	0.40	0.60	0.30	0.30
2	....	....	....	1.10	1.20	.90	1.50	1.40	1.20	1.70	1.90	1.30	.60	.50	.30	.60	.30	.30
3	....	....	....	1.20	1.30	1.00	1.60	1.60	1.40	1.70	2.00	1.40	.60	.50	.30	.40	.20	.30
4	....	....	....	1.40	1.80	1.10	1.60	1.70	1.50	1.70	2.00	1.40	.60	.50	.30	.40	.20	.30
5	....	....	....	1.30	1.50	1.70	1.50	1.60	1.40	1.70	1.90	1.40	.60	.40	.30	.30	.20	.10
6	....	....	....	1.40	1.60	1.20	1.40	1.50	1.30	1.60	1.70	1.20	.60	.40	.30	.30	.20	.10
7	....	....	....	1.40	1.60	1.20	1.40	1.50	1.30	1.50	1.60	1.10	.70	.40	.30	.20	.10	.10
8	....	....	....	1.20	1.40	1.00	1.40	1.50	1.30	1.40	1.50	1.10	.70	.40	.30	.20	.10	.20
9	....	....	....	1.00	1.10	.80	1.40	1.50	1.30	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
10	....	....	....	1.00	1.10	.80	1.50	1.40	1.20	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
11	....	....	....	1.40	1.30	1.00	1.60	1.70	1.40	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
12	....	....	....	1.30	1.40	1.10	1.40	1.40	1.20	1.30	1.40	1.00	.70	.30	.30	.10	.20	.30
13	....	....	....	1.60	2.50	1.50	1.30	1.30	1.10	1.30	1.30	1.00	.70	.30	.30	.10	.20	.30
14	....	....	....	1.30	2.00	1.20	1.30	1.20	1.00	1.30	1.30	1.00	.70	.30	.30	.10	.20	.30
15	....	....	....	1.20	1.80	1.30	1.30	1.20	1.00	1.20	1.30	1.00	.70	.30	.20	.10	.20	.30
16	....	....	....	1.20	1.60	1.20	1.30	1.20	1.00	1.10	1.20	.90	.70	.30	.20	....	....	.....
17	....	....	....	1.30	1.80	1.30	1.40	1.20	1.00	1.10	1.20	.90	.70	.30	.20	....	....	.....
18	....	....	....	1.20	1.50	1.20	1.40	1.20	1.00	.90	1.10	.80	.70	.30	.20	....	....	.....
19	....	....	....	1.30	1.40	1.20	1.40	1.20	1.00	.90	1.10	.80	.70	.30	.20	....	....	.....
20	....	....	....	1.40	1.40	1.30	1.40	1.20	.90	.90	1.00	.70	.70	.30	.30	....	....	.....
21	....	....	....	1.40	1.40	1.20	1.40	1.20	.90	.90	.90	.80	.70	.30	.30	....	....	.....
22	....	....	....	1.40	1.40	1.30	1.40	1.30	1.00	.90	.90	.80	.70	.30	.30	....	....	.....
23	....	....	....	1.50	1.30	1.10	1.50	1.40	1.10	.90	.90	.80	.70	.30	.30	....	....	.....
24	....	....	....	1.50	1.30	1.10	1.60	1.50	1.30	.90	.90	.80	.60	.30	.30	....	....	.....
25	....	....	....	1.50	1.30	1.10	1.60	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
26	....	....	....	1.50	1.40	1.30	1.70	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
27	....	....	....	1.60	1.50	1.40	1.70	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
28	....	....	....	1.50	1.40	1.20	1.60	1.70	1.20	.70	.70	.50	.60	.30	.30	....	....	.....
29	2.50	2.70	2.50	1.50	1.50	1.30	1.60	1.80	1.30	.70	.60	.40	.60	.30	.30	....	....	.....
30	2.40	2.60	2.40	1.50	1.40	1.20	1.80	2.10	1.30	.70	.60	.40	.60	.30	.30	....	....	.....
31	2.30	2.40	2.30	.....	.....	.....	1.80	1.90	1.30	.....	.....	.....	.60	.30	.30	....	....	.....

Little Wood River at Taponis, Idaho.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	.....	.....	1.50	11	.....	.....	1.20	1.33	22	.....	.....	.....	2.58
2	6.90	.....	.....	.....	12	6.40	.....	.....	.....	23	6.40	.....	.....	.....
3	.....	4.40	.....	.....	14	6.40	4.30	1.20	.....	24	.....	5.67	.....	.....
4	.....	.....	1.20	2.08	15	.....	.....	.....	2.17	25	.....	.....	.....	2.67
5	7.10	.....	.....	.....	16	6.70	.....	.....	.....	26	5.20	.....	.....	.....
7	.....	3.90	1.00	.....	17	.....	4.50	.....	.....	28	5.30	6.33	.....	.....
8	.....	.....	.....	1.33	18	.....	.....	1.20	2.33	29	.....	.....	.....	2.75
9	6.40	.....	.....	.....	19	6.90	.....	.....	.....	30	4.10	.....	.....	.....
10	.....	4.30	.....	.....	21	6.70	5.00	.....	.....	31	.....	7.17	.....	.....

Bruneau River at Owyhee, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	1.65	1.75	1.75	2.45	2.90	6.40	17	1.65	1.60	1.75	3.20	2.80	4.70
2	1.65	1.75	1.75	2.40	2.90	6.70	18	1.70	1.60	1.75	3.00	2.70	4.60
3	1.65	1.75	1.75	2.40	2.95	6.00	19	1.70	1.65	1.75	2.90	2.65	4.60
4	1.65	1.75	1.75	2.35	2.90	5.90	20	1.75	1.65	1.80	2.85	2.60	4.30
5	1.60	1.75	1.75	2.35	2.90	5.35	21	1.75	1.70	1.80	2.75	2.60	4.20
6	1.60	1.75	1.80	2.35	3.30	5.00	22	1.75	1.70	1.95	2.75	2.60	4.00
7	1.60	1.75	1.80	2.40	3.25	4.95	23	1.75	1.70	2.40	2.90	2.60	3.80
8	1.65	1.75	1.80	2.55	3.20	4.80	24	1.75	1.70	2.45	2.90	2.90	3.70
9	1.65	1.70	1.80	2.60	3.15	4.70	25	1.75	1.70	2.75	2.90	2.95	3.60
10	1.65	1.70	1.80	2.65	3.00	5.00	26	1.75	1.70	3.20	2.90	3.20	3.45
11	1.65	1.70	1.75	2.65	3.00	5.20	27	1.75	1.70	3.35	3.00	3.80	3.35
12	1.65	1.70	1.75	2.55	3.00	4.90	28	1.75	1.70	3.55	3.15	4.00	3.30
13	1.65	1.70	1.75	2.40	3.15	4.65	29	1.75	1.70	3.35	3.00	4.50	3.20
14	1.65	1.70	1.75	2.80	3.00	4.60	30	1.75	.....	3.00	2.90	5.30	3.15
15	1.65	1.70	1.75	3.85	2.95	4.65	31	1.75	.....	2.85	.....	6.00	.....
16	1.65	1.70	1.75	3.60	2.95	4.60							

Boise River at Boise, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.70	2.60	4.40	5.30	9.00	6.30	3.30	2.20	1.70	1.90	1.20
2	2.00	2.40	2.40	3.90	5.00	9.00	6.80	3.00	2.20	1.80	2.00	1.10
3	1.40	2.40	2.40	3.80	5.30	9.60	7.00	3.30	2.00	1.60	1.90	1.10
4	1.40	2.00	2.30	3.80	6.00	9.30	7.00	2.90	1.90	1.60	1.90	1.40
5	1.40	2.00	2.40	3.90	6.00	9.00	6.80	2.80	1.80	1.70	1.70	2.00
6	1.40	1.80	2.00	3.90	5.60	8.70	6.70	2.80	1.80	1.60	1.70	2.40
7	1.40	1.80	2.00	4.60	5.70	8.70	6.60	2.70	1.80	1.80	1.50	2.40
8	1.80	2.00	2.20	4.80	5.80	8.80	6.50	2.70	1.70	1.70	1.90	2.60
9	1.80	2.00	2.40	4.40	5.60	8.60	6.30	2.70	1.70	1.60	2.60	2.60
10	1.80	2.00	2.20	5.00	5.40	8.80	6.20	2.60	1.70	1.60	2.30	2.40
11	1.80	1.90	2.30	4.50	5.50	8.50	6.10	2.60	1.80	1.70	2.00	2.00
12	2.00	2.00	2.30	4.50	5.40	8.50	6.10	2.40	1.80	1.60	1.90	2.60
13	1.80	2.00	2.40	5.70	5.20	9.30	5.90	2.30	1.70	1.60	1.90	2.70
14	1.40	1.90	2.40	6.70	5.00	10.00	5.80	2.20	1.80	1.60	1.90	2.80
15	1.40	2.00	2.40	5.80	5.00	9.60	5.60	2.20	1.80	1.70	2.00	2.50
16	1.20	2.00	2.40	5.50	5.00	9.60	5.40	2.20	1.80	1.60	1.90	2.50
17	1.90	1.90	2.30	5.40	4.90	9.60	5.00	2.20	1.70	1.60	1.90	2.40
18	2.30	1.90	2.40	5.00	4.80	9.50	4.80	2.00	1.70	1.70	2.00	2.40
19	2.40	2.00	2.40	4.80	4.70	9.40	4.60	2.00	1.80	1.70	2.60	2.20
20	2.50	2.00	2.70	4.50	4.70	9.00	4.00	1.90	1.70	1.60	2.80	2.20
21	3.00	2.00	3.50	4.40	4.60	9.00	3.60	1.90	1.70	1.60	2.40	2.00
22	3.00	2.10	3.90	5.00	5.00	8.50	3.00	1.80	1.60	1.70	2.70	2.00
23	3.00	2.10	4.00	5.10	5.80	8.00	3.60	1.90	1.70	1.70	2.70	1.90
24	2.40	2.10	4.60	5.10	6.70	7.50	4.00	1.90	1.90	1.70	2.90	1.90
25	2.30	2.20	4.60	5.40	7.00	7.30	4.00	1.80	2.00	1.60	2.60	1.80
26	2.60	2.20	5.60	5.80	7.40	7.30	3.40	1.90	.....	1.60	2.40	1.80
27	2.80	2.30	6.10	5.30	7.40	9.00	3.20	1.80	1.90	1.80	2.00	2.00
28	2.90	2.90	5.70	5.20	8.00	6.80	3.00	1.90	1.90	1.80	1.60	2.00
29	2.80	3.00	5.50	5.30	8.10	6.40	3.40	1.90	1.80	1.80	1.40	2.10
30	2.80	.....	4.60	5.10	8.60	6.40	3.40	2.00	1.70	1.60	1.40	2.10
31	2.70	.....	4.50	.....	9.50	.....	3.30	2.20	.....	1.90	.....	2.10

Boise River at Caldwell, Idaho.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	5.75	6.40	11.00	8.20	4.40	3.65
2	.....	5.60	6.50	11.00	7.80	4.40	3.60
3	.....	5.55	6.40	11.30	7.70	4.30	3.60
4	4.40	5.50	7.00	11.00	7.60	4.25	3.55
5	4.40	5.60	7.60	10.00	7.40	4.20	3.50
6	4.30	5.80	7.40	9.90	7.40	4.20	3.50
7	4.30	5.90	7.10	9.50	7.30	4.15	3.45
8	4.30	6.00	7.00	9.20	7.20	4.10	3.45
9	4.30	6.00	7.00	9.90	7.00	4.10	3.45
10	4.35	5.90	6.90	10.20	6.95	4.00	3.45
11	4.40	5.80	7.00	9.80	6.80	3.90	3.45
12	4.40	5.90	6.80	9.60	6.70	3.90	3.45
13	4.40	6.30	6.60	9.80	6.75	3.85	3.50
14	4.50	8.00	6.50	10.00	6.60	3.80	3.50
15	4.45	7.40	6.40	9.90	6.50	3.70	3.45
16	4.45	6.90	6.30	10.00	6.30	3.70	3.40
17	4.50	6.60	6.40	10.00	6.10	3.65	3.40
18	4.55	6.50	6.20	10.30	5.90	3.60	3.40
19	4.60	6.20	6.10	10.00	5.70	3.60	3.45
20	4.85	6.20	6.00	9.80	5.40	3.55	3.40
21	5.40	6.15	6.00	9.40	5.30	3.50	3.45
22	5.70	6.10	6.10	9.00	5.20	3.50	3.45
23	5.75	6.15	6.80	8.60	5.10	3.50	3.50
24	6.00	6.30	7.60	8.40	5.00	3.45	3.65
25	7.10	6.60	8.00	8.30	4.90	3.40	3.70
26	7.10	6.80	8.50	8.10	4.80	3.35	3.65
27	7.70	6.70	8.60	8.00	4.70	3.30	3.60
28	7.30	6.60	8.90	8.20	4.70	3.25	3.60
29	6.70	6.50	9.10	8.10	4.60	3.20	3.55
30	6.35	6.55	10.00	8.00	4.50	3.20	3.50
31	5.90	.....	11.00	.....	4.50	3.30	.....

Owyhee River at Nyssa, Oregon.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.30	1.60	.....	3.65	5.75	2.25	1.05	1.30	1.10	.....
2	1.30	1.50	.....	3.60	5.45	2.15	1.00	1.30	1.10	.....
3	1.30	1.50	.....	3.85	5.00	2.05	1.00	1.30	1.10	.....
4	1.30	1.40	.....	4.05	4.70	1.95	1.00	1.20	.....	.....
5	1.40	1.40	.....	4.35	4.55	1.90	1.00	1.20	.....	.....
6	1.40	1.50	.....	4.45	4.45	1.85	1.00	1.10	.....	.....
7	1.40	1.50	.....	4.65	4.35	1.80	1.00	1.10	.....	.....
8	1.40	1.50	.....	4.80	4.30	1.75	1.00	1.00	.....	.....
9	1.40	1.40	.....	4.90	4.25	1.70	.95	1.00	.....	.....
10	1.40	1.40	.....	4.80	4.15	1.65	.95	.90	.....	.....
11	1.40	1.40	.....	4.80	4.15	1.60	.95	.90	.....	.....
12	1.40	1.40	.....	4.70	4.05	1.50	.95	.90	.....	.....
13	1.40	1.35	.....	4.65	3.95	1.45	.95	.95	.....	.....
14	1.55	1.30	.....	4.60	3.55	1.40	.95	.95	.....	.....
15	1.75	1.30	.....	4.55	3.45	1.40	.95	1.00	.....	.....
16	2.50	1.30	.....	4.50	3.35	1.35	.90	1.00	.....	.....
17	5.65	1.30	.....	4.40	3.30	1.30	.90	1.00	.....	1.20
18	3.80	1.30	.....	4.40	3.25	1.25	.90	1.00	.....	1.20
19	3.35	1.30	.....	4.55	3.15	1.20	.90	1.00	.....	1.20
20	3.05	1.40	.....	4.60	3.05	1.20	.90	1.00	.....	1.20
21	2.75	1.40	.....	4.65	2.95	1.20	.90	1.00	.....	1.20
22	2.55	1.40	.....	4.75	2.90	1.10	.90	1.00	.....	1.20
23	2.45	1.50	.....	4.85	2.85	1.10	1.00	.95	.....	1.20
24	2.40	1.50	.....	5.05	2.80	1.10	1.00	.95	.....	.....
25	2.35	1.55	.....	5.25	2.75	1.00	1.10	1.00	.....	.....
26	2.05	1.60	3.40	5.45	2.70	1.20	1.10	1.00	.....	.....
27	1.85	1.60	3.45	5.65	2.65	1.20	1.20	1.00	.....	.....
28	1.80	1.60	3.55	5.85	2.45	1.15	1.20	1.00	.....	.....
29	1.75	1.60	3.65	5.95	2.40	1.10	1.30	1.00	.....	.....
30	1.70	.....	3.70	6.05	2.35	1.10	1.40	1.00	.....	.....
31	1.60	.....	.....	6.00	.....	1.10	1.40	.....	.....	.....

Malheur River at Vale, Oregon.

Day.	Jan. *a*	Feb.	Apr.	May.	June.	July.	Aug.	Sept.
1	1.70	2.55	.....	3.00	4.30	2.45	1.00	1.60
2	1.75	2.65	.....	3.00	4.35	2.35	.95	1.45
3	1.80	2.70	.....	3.05	4.50	2.30	.90	1.20
4	1.90	2.60	.....	3.10	4.50	2.25	.90	1.10
5	1.90	2.60	.....	3.85	4.45	2.15	.90	1.10
6	1.90	2.50	.....	4.90	4.30	2.10	.85	1.10
7	1.85	2.50	.....	4.65	4.25	2.10	.75	1.10
8	1.90	2.40	.....	4.05	4.25	2.05	.70	1.10
9	1.85	2.35	.....	3.85	4.10	1.95	.70	1.10
10	1.85	2.25	.....	3.80	4.05	1.90	.71	1.10
11	1.70	2.20	.....	3.70	3.90	1.85	.72	1.10
12	1.70	2.10	.....	3.70	3.75	1.80	.72	1.10
13	1.70	2.00	.....	3.75	3.70	1.85	.71	1.10
14	1.70	2.00	.....	3.65	3.60	1.90	.71	1.10
15	1.70	2.00	.....	3.45	3.50	1.95	.71	1.10
16	1.75	2.00	.....	3.30	3.50	1.90	.70	1.10
17	5.00	2.00	.....	3.30	3.50	1.90	.70	1.10
18	.....	2.05	.....	3.30	3.40	1.65	.70	1.10
19	.....	2.10	.....	3.30	3.35	1.60	.70	1.10
20	.....	2.10	.....	3.20	3.40	1.50	.70	1.15
21	.....	2.00	.....	3.15	3.35	1.50	.70	1.20
22	.....	1.95	.....	3.10	3.30	1.45	.70	1.20
23	.....	2.05	.....	3.10	3.25	1.40	.70	1.20
24	.....	2.20	.....	3.25	3.15	1.40	.70	1.20
25	3.20	2.30	.....	3.55	3.05	1.30	.69	1.20
26	3.10	2.15	2.90	3.75	3.40	1.30	.68	1.20
27	2.90	2.20	3.00	3.90	3.35	1.25	.68	1.25
28	2.75	2.30	3.00	4.00	2.75	1.20	.70	1.25
29	2.60	2.95	3.00	4.10	2.65	1.15	.70	1.25
30	2.55	.....	3.00	4.20	2.55	1.10	.70	1.25
31	2.65	.....	.....	4.20	.....	1.00	2.20	.....

a January 16 to 25 gage broken; no readings.

Payette River at Payette, Idaho.

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1	.....	8.20	7.50	2.20	1.90	17	3.70	8.90	4.90	1.60	1.10
2	.....	8.30	7.40	2.20	1.80	18	3.60	9.20	4.30	1.60	1.10
3	.....	9.10	7.20	2.10	1.70	19	3.60	9.20	3.90	1.50	1.00
4	.....	9.30	6.80	2.10	1.40	20	3.30	9.10	3.70	1.50	1.00
5	.....	9.10	6.80	2.10	1.30	21	3.40	9.00	3.50	1.40	1.00
6	.....	9.20	6.50	2.00	1.30	22	4.20	8.80	3.30	1.40	1.00
7	.....	8.60	6.40	2.00	1.20	23	5.40	7.60	3.10	1.40	1.10
8	.....	8.40	6.20	1.90	1.20	24	5.40	7.90	2.90	1.30	1.10
9	.....	8.70	6.00	1.90	1.10	25	5.60	7.50	2.80	1.30	1.10
10	.....	8.90	5.70	1.80	1.10	26	5.90	7.40	2.70	1.20	1.10
11	.....	8.50	5.70	1.80	1.10	27	6.10	7.40	2.60	1.20	1.00
12	4.20	8.40	5.50	1.80	1.10	28	6.50	7.20	2.50	1.10	.90
13	4.30	8.30	6.20	1.80	1.10	29	6.90	7.40	2.50	1.10	.90
14	4.00	8.70	5.90	1.70	1.10	30	7.20	7.50	2.40	1.20	.90
15	3.70	8.80	5.50	1.70	1.10	31	7.70	.....	2.30	1.30	.....
16	3.70	8.80	5.30	1.70	1.10						

Yakima River at Kiona, Washington.

Day.	Jan.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Jan.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.30	.....	4.73	4.08	4.24	5.95	17	.....	5.10	4.48	4.00	15.18	9.20
2	5.35	6.10	4.73	4.05	4.35	6.10	18	.....	5.05	4.50	3.96	16.07	8.70
3	5.20	6.15	4.70	4.05	4.40	6.50	19	.....	5.00	4.55	3.94	13.35	8.52
4	5.10	6.10	4.70	4.10	4.46	7.10	20	.....	4.95	4.45	3.93	10.91	8.43
5	5.35	6.05	4.70	4.10	4.47	8.90	21	.....	4.90	4.35	3.92	9.50	8.31
6	5.40	6.00	4.68	4.05	4.51	9.80	22	.....	4.85	4.30	3.89	9.20	8.30
7	5.55	5.90	4.65	4.08	4.52	11.45	23	6.35	4.80	4.30	3.87	8.30	8.21
8	5.90	5.80	4.65	4.10	4.52	11.55	24	6.15	4.75	4.25	3.87	7.93	8.03
9	6.70	5.70	4.63	4.08	4.56	.....	25	6.05	4.75	4.20	3.94	7.62	7.90
10	8.20	5.60	4.55	4.05	5.80	11.30	26	.....	4.70	4.20	3.91	7.23	7.70
11	8.80	5.60	4.55	4.08	5.80	10.80	27	.....	4.70	4.20	3.93	6.65	7.55
12	8.80	5.50	4.50	4.04	5.72	10.60	28	.....	4.70	4.18	3.88	5.93	7.45
13	8.00	5.35	4.50	4.00	5.60	10.65	29	.....	4.70	4.15	3.94	5.95	7.35
14	7.60	5.30	4.48	4.00	5.60	10.70	30	.....	4.70	4.13	*a*	5.95	7.15
15	7.15	5.20	4.50	4.01	8.68	10.07	31	.....	4.70	.....	3.94	.....	7.05
16	.....	5.15	4.50	3.95	11.91	9.50							

a No observation.

Weiser River at Weiser, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.30	4.00	3.80	4.30	4.10	7.10	4.90	2.00	1.80	1.80
2	2.30	3.70	3.50	4.00	5.20	7.10	4.70	2.00	1.80	1.80
3	2.30	3.00	3.20	3.80	5.10	7.10	4.60	2.00	1.80	1.70
4	2.30	3.20	3.00	3.70	8.30	7.40	4.40	2.00	1.90	1.70
5	2.30	3.10	3.00	3.70	9.20	7.00	4.20	2.00	1.90	1.70
6	2.30	3.00	2.90	3.80	9.10	7.90	4.00	2.00	1.90	1.70
7	2.40	2.90	2.90	4.10	8.50	8.90	3.80	2.00	1.90	1.70
8	2.40	2.80	3.00	4.50	7.40	7.60	3.60	2.00	1.90	1.70
9	2.40	2.70	3.30	4.70	6.70	6.70	3.50	2.00	1.90	1.70
10	2.30	2.60	3.70	4.50	5.90	6.70	3.40	1.90	1.90	1.70
11	2.30	2.60	4.00	4.30	6.00	6.60	3.30	1.90	1.90	1.70
12	2.30	2.50	3.80	4.10	6.40	6.60	3.20	1.90	1.90	1.70
13	2.30	2.50	3.80	4.60	5.50	6.50	3.10	1.90	2.00	1.70
14	2.30	2.50	3.70	4.50	5.00	6.40	3.00	1.90	2.00	1.70
15	2.30	2.50	3.50	5.20	4.70	6.40	2.90	1.80	2.00	1.70
16	2.50	2.60	3.40	4.80	4.60	6.40	2.80	1.80	2.00	1.70
17	5.10	2.60	3.30	4.50	4.70	6.40	2.70	1.80	2.00	1.70
18	5.50	2.70	3.30	4.10	5.20	6.50	2.60	1.80	2.00	.....
19	6.50	2.70	3.40	4.00	4.70	6.60	2.50	1.80	2.00	.....
20	7.60	2.70	3.80	3.90	4.60	6.40	2.40	1.80	1.90	.....
21	8.30	2.70	4.60	3.80	4.60	6.20	2.40	1 90	1.90	.....
22	7.40	2.80	4.70	3.70	4.70	5.90	2.30	1.80	1.90	.....
23	5.80	2.90	4.70	3.80	5.10	5.80	2.30	1.80	1.90	.....
24	4.50	2.90	5.20	3.90	5.60	5.60	2.20	1.80	1.80	.....
25	3.80	3.00	6.00	4.10	6.10	5.40	2.20	1.80	1.80	.....
26	3.80	3.20	6.00	4.40	6.10	5.20	2.20	1.80	1.80	.....
27	4.00	4.00	6.50	4.70	6.10	4.90	2.10	1.80	1.80	.....
28	4.40	4.45	6.20	4.90	6.20	5.20	2.10	1.80	1.80	.....
29	6.40	4.10	5.60	4.50	6.20	5.30	2.10	1.80	1.80	.....
30	5.70	.....	5.00	4.20	6.60	5.20	2.10	1.80	1.80	.....
31	4.50	.....	4.60	.....	6.90	.....	2.00	1.80	.....	.....

Natches River at North Yakima, Washington.

Day.	Jan.	Feb.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	1.90	.....	3.25	1.50	1.10	1.50	3.60
2	1.60	.....	.....	3.10	1.40	1.20	1.40	3.80
3	1.60	1.90	.....	3.00	1.40	1.20	1.30	4.00
4	1.60	1.90	.....	2.90	1.40	1.20	1.20	4.50
5	.....	1.90	.....	3.00	1.40	1.10	1.10	5.00
6	2.00	2.00	.....	2.85	1.30	.90	1.00	4.90
7	2.90	2.00	.....	2.80	1.30	.89	1.20	4.70
8	3.20	1.90	.....	2.70	1.30	.88	2.20	4.50
9	3.90	.....	.....	2.65	1.30	.87	2.50	4.30
10	4.10	1.90	.....	2.45	1.25	.86	2.40	4.10
11	3.80	1.90	.....	2.35	1.20	.85	2.30	4.00
12	.....	1.90	.....	2.20	1.30	.84	2.15	3.90
13	3.10	1.90	.....	2.10	1.30	.83	2.00	3.70
14	2.90	2.00	.....	2.05	1.35	.82	4.25	3.60
15	2.80	1.90	.....	2.00	1.50	.81	8.00	3.50
16	2.80	.....	.....	1.90	1.40	.80	7.75	3.50
17	2.70	2.10	.....	1.80	1.30	.79	6.25	3.40
18	2.70	2.10	.....	1.80	1.30	.72	5.25	3.40
19	.....	2.70	.....	1.70	1.20	.74	4.70	3.30
20	2.60	2.80	.....	1.70	1.20	.76	4.30	3.30
21	2.40	2.90	.....	1.60	1.20	.76	4.00	3.30
22	2.30	3.20	.....	1.60	1.25	.60	3.80	3.20
23	2.20	.....	.....	1.50	1.30	.60	3.70	3.20
24	2.20	3.20	.....	1.50	1.20	.60	3.60	3.20
25	2.10	3.90	.....	1.50	1.10	.50	3.50	3.10
26	.....	5.60	.....	1.50	.90	.50	3.35	3.10
27	2.20	6.20	.....	1.50	.90	.60	3.15	3.10
28	2.20	5.80	3.35	1.50	.90	.75	3.00	3.00
29	2.20	5.80	3.25	1.50	.90	.95	3.20	3.00
30	1.90	.....	3.10	1.50	1.10	1.15	3.40	3.00
31	1.90	.....	3.15	1.50	.....	1.40	.....	3.00

Yakima River at Yakima, Washington.

Day.	Jan.	Feb.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.75	4.70	5.80	4.80	4.50	4.50	6.60
2	4.70	.....	5.80	4.80	4.50	4.50	7.60
3	4.70	4.70	5.70	4.80	4.50	4.50	8.20
4	4.70	4.70	5.70	4.80	4.50	4.60	7.70
5	.....	4.80	5.60	4.80	4.50	4.90	6.60
6	4.80	4.90	5.60	4.80	4.50	5.00	6.70
7	5.10	4.90	5.50	4.80	4.50	5.30	6.80
8	5.50	4.85	5.50	4.80	4.50	5.60	6.90
9	6.50	.....	5.50	4.80	4.40	5.80	8.00
10	7.20	4.80	5.40	4.80	4.40	5.90	8.20
11	6.80	4.80	5.40	4.70	4.40	5.70	8.60
12	.....	4.80	5.30	4.70	4.40	5.70	8.40
13	6.40	4.90	5.30	4.70	4.40	5.80	8.20
14	6.10	5.00	5.20	4.70	4.40	5.80	8.00
15	5.90	5.00	5.20	4.70	4.40	13.00	7.60
16	5.70	.....	5.10	4.70	4.40	15.00	7.40
17	5.60	5.20	5.10	4.70	4.40	14.00	7.10
18	5.50	5.30	5.10	4.70	4.40	12.00	6.80
19	.....	5.35	5.00	4.70	4.40	9.00	6.20
20	5.40	5.40	5.00	4.70	4.40	8.00	6.10
21	5.30	5.40	5.00	4.70	4.40	7.00	6.10
22	5.20	5.40	4.90	4.65	4.40	6.80	6.00
23	5.10	.....	4.90	4.60	4.40	6.60	6.00
24	5.10	5.60	4.90	4.60	4.40	6.40	5.90
25	5.05	6.20	4.90	4.60	4.40	6.20	5.90
26	.....	6.70	4.80	4.50	4.40	6.10	5.80
27	5.00	7.80	4.80	4.50	4.40	6.00	5.80
28	4.90	7.70	4.80	4.50	4.40	6.00	5.70
29	4.85	7.40	.....	4.50	4.40	6.00	5.70
30	4.80	.....	.....	4.50	4.40	6.00	5.60
31	4.75	.....	.....	.....	4.50	.....	5.60

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1891.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.08	5.00	3.83	1.50	0.33	1.00	0.50	2.75	3.83
2	.....	2.08	5.00	3.67	1.58	.25	1.00	.50	2.83	4.00
3	.....	2.17	4.92	3.50	1.58	.25	1.00	.50	3.00	4.00
4	.....	2.17	4.67	3.33	1.50	.25	1.00	.50	3.17	3.75
5	.....	2.17	4.50	3.17	1.50	.17	.92	.50	3.33	3.83
6	.....	2.17	4.50	3.17	1.50	.17	.92	.50	3.33	3.83
7	.....	2.17	4.67	3.00	1.33	.17	.92	.50	3.42	3.83
8	.....	2.50	4.83	3.00	1.33	.08	.92	.50	3.42	3.83
9	.....	2.75	5.00	2.92	1.25	.08	.83	.50	3.50	3.83
10	.....	2.92	5.00	2.83	1.25	.08	.83	.50	3.50	3.83
11	.....	2.92	5.25	2.75	1.25	.08	.83	.50	3.50	3.83
12	.....	2.92	5.00	2.67	1.25	.00	.83	.50	3.50	3.75
13	.....	3.17	5.00	2.50	1.17	.00	.83	.50	3.58	3.75
14	.....	3.33	5.00	2.50	1.17	1.33	.75	.50	3.58	3.75
15	.....	3.50	5.00	2.50	1.17	1.33	.75	.50	3.67	3.75
16	.....	3.75	5.17	2.42	1.17	1.33	.75	.50	3.67	3.75
17	.....	3.92	5.17	2.33	1.08	1.33	.75	.50	3.67	3.75
18	.....	4.08	5.25	2.25	1.00	1.33	.75	.50	3.75	3.83
19	.....	4.50	5.25	2.17	1.00	1.33	.67	1.08	3.75	3.83
20	.....	4.92	5.17	2.08	1.00	1.25	.67	2.67	3.75	3.83
21	.....	4.50	5.08	2.00	.92	1.25	.67	2.67	3.83	3.83
22	0.58	4.58	5.00	2.00	.83	1.25	.58	2.67	3.83	3.83
23	.92	4.67	4.83	1.92	.83	1.25	.58	2.67	3.83	3.83
24	1.25	4.83	4.83	1.92	.75	1.17	.58	2.67	3.83	3.83
25	1.42	4.83	4.50	1.83	.67	1.17	.58	2.67	3.83	3.83
26	1.58	4.83	4.42	1.75	.67	1.17	.50	2.67	3.83	3.83
27	1.75	4.83	4.25	1.67	.67	1.17	.50	2.67	3.83	3.83
28	1.92	4.83	4.00	1.67	.50	1.08	.50	2.67	3.83	3.83
29	2.00	4.83	4.00	1.67	.42	1.08	.50	2.67	3.83	3.83
30	2.08	5.00	4.00	1.67	.42	1.08	.50	2.67	3.83	3.83
31	2.08	.....	3.83	.....	.33	1.08	.....	2.75	.....	3.83

March 22, waste gates almost entirely closed. April 21, waste gates opened, which lowered the water about 1 foot. August 14, waste gates partly closed, one open about 2 feet 6 inches, the other, 3 feet 6 inches. October 19, waste gates further closed, one open about 8 inches, the other 1 foot. October 20, flashboards put on dam about three-fourths of the way across. December 4, about one-third of the flashboards were carried out.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.83	3.33	3.08	4.58	4.42	8.00	4.33	1.58	0.92	3.00	3.00	4.00
2	3.67	3.17	3.17	4.42	4.42	8.00	4.25	2.33	.92	3.00	3.00	4.00
3	3.67	3.17	3.25	4.33	4.42	8.00	4.17	2.33	.92	3.00	3.00	4.08
4	3.67	3.17	3.33	4.08	4.42	7.92	4.08	2.17	.83	3.00	3.00	4.08
5	3.67	3.17	3.42	3.92	4.50	7.83	4.00	2.08	.83	3.00	3.00	4.17
6	3.67	3.17	3.50	3.83	4.58	7.67	3.92	2.00	.75	3.00	3.00	4.17
7	3.67	3.17	3.50	3.75	4.67	7.58	3.83	1.92	.75	3.00	3.00	4.25
8	3.67	3.17	3.50	3.75	4.75	7.42	3.75	1.83	.75	3.00	3.00	4.25
9	3.67	3.17	3.58	3.75	4.83	7.25	3.67	1.75	.67	3.00	3.00	4.25
10	3.67	3.17	3.67	3.75	4.92	7.00	3.58	1.67	.67	3.00	3.00	4.25
11	3.50	3.17	3.83	3.75	5.08	6.75	3.50	1.67	.67	3.00	3.00	4.25
12	3.50	3.25	4.00	3.75	5.33	6.67	3.33	1.58	.58	3.00	3.00	4.25
13	3.50	3.25	4.33	3.75	5.58	6.58	3.25	1.58	.50	3.00	3.00	4.25
14	3.50	3.25	4.67	3.83	5.75	6.50	3.17	1.50	.42	3.00	3.00	4.25
15	3.50	3.25	4.92	3.92	5.92	6.33	3.08	1.50	.33	3.00	3.00	4.17
16	3.50	3.25	5.17	4.00	6.00	6.25	3.00	1.50	.25	3.00	3.08	4.17
17	3.50	3.25	5.33	4.08	6.08	6.08	2.92	1.42	.00	3.00	3.17	4.17
18	3.50	3.25	5.50	4.17	6.17	6.00	2.83	1.42	.00	3.00	3.17	4.08
19	3.50	3.25	5.67	4.25	6.25	5.83	2.75	1.42	3.00	3.00	3.25	4.08
20	3.50	3.25	5.75	4.25	6.33	5.67	2.67	1.33	3.00	3.00	3.25	4.00
21	3.50	3.25	5.75	4.25	6.42	5.50	2.58	1.33	3.00	3.00	3.33	3.92
22	3.50	3.25	5.75	4.25	6.58	5.33	2.50	1.33	3.00	3.00	3.33	3.92
23	3.50	3.33	5.67	4.25	6.83	5.25	2.33	1.25	3.00	3.00	3.42	3.83
24	3.33	3.50	4.75	4.25	7.00	5.08	2.17	1.25	3.00	3.00	3.50	3.83
25	3.33	3.75	4.83	4.25	7.33	5.00	2.00	1.17	3.00	3.00	3.58	3.83
26	3.33	3.92	4.83	4.33	7.67	4.83	1.83	1.17	3.00	3.00	3.67	3.92
27	3.33	4.00	4.83	4.33	7.75	4.75	1.75	1.08	3.00	3.00	3.75	3.92
28	3.33	3.75	4.83	4.33	7.92	4.67	1.67	1.08	3.00	3.00	3.83	3.92
29	3.33	3.00	4.83	4.33	8.00	4.58	1.58	1.00	3.00	3.00	3.92	4.00
30	3.33	.....	4.83	4.42	8.00	4.50	1.58	1.00	3.00	3.00	3.92	4.00
31	3.33	.....	4.75	.....	8.00	.....	1.58	1.00	3.00	3.00	.....	4.08

February 28, part of the flashboards taken out. February 29, balance taken out. March 24, waste gates opened full. August 2, one waste gate partly closed, leaving opening 3 feet 6 inches; openings partly closed with drift logs. September 17, logs removed from waste gates. September 19, waste gates closed and flashboards put on dam.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.08	3.92	3.58	3.50	6.17	8.25	5.25	1.83	0.33	3.25	5.00	4.92
2	4.17	3.83	3.58	3.75	6.33	8.25	5.17	1.75	.33	3.33	5.00	4.92
3	4.17	3.83	3.58	4.08	6.50	8.25	5.00	1.75	.25	3.42	4.92	4.83
4	4.25	3.83	3.58	4.33	6.67	8.25	5.00	1.67	.25	3.50	4.83	4.83
5	4.33	3.75	3.58	4.67	6.75	8.25	4.92	1.67	.25	3.58	4.83	4.83
6	4.42	3.75	3.58	4.00	6.83	8.00	4.83	1.67	.17	3.67	4.92	4.83
7	4.50	3.75	3.58	4.42	6.92	8.00	4.75	1.58	.08	3.83	5.17	4.83
8	4.50	3.75	3.67	4.75	7.00	8.00	4.67	1.58	.08	4.00	5.67	4.83
9	4.58	3.67	.67	4.83	7.17	8.00	4.58	1.50	.00	4.25	6.17	5.17
10	4.58	3.67	.67	5.08	7.33	8.00	4.42	1.50	.00	4.50	6.50	5.67
11	4.58	3.58	.67	5.08	7.50	7.92	4.25	1.50	.00	4.75	6.67	6.00
12	4.58	3.58	.67	5.08	7.75	7.83	4.00	1.42	3.25	5.00	6.75	6.83
13	4.58	3.58	1.33	4.92	7.75	7.75	3.92	1.42	3.25	5.00	6.83	7.00
14	4.50	3.58	1.50	4.92	8.00	7.58	3.75	1.33	3.17	5.00	6.83	7.00
15	4.50	3.58	1.67	4.75	8.25	7.42	3.58	1.25	3.17	5.00	6.83	6.92
16	4.50	3.58	1.67	4.67	8.75	7.25	3.42	1.17	3.17	5.08	6.75	6.83
17	4.42	3.58	1.67	4.50	9.00	7.00	3.25	1.08	3.17	5.08	6.67	6.67
18	4.42	3.58	1.67	4.42	9.25	6.92	3.08	1.00	3.17	5.08	6.50	6.50
19	4.33	3.58	1.67	4.33	10.00	6.75	3.00	.92	3.17	5.08	6.38	6.33
20	4.25	3.58	1.67	4.25	10.25	6.58	2.92	.83	3.17	5.17	6.08	6.17
21	4.25	3.58	1.67	4.25	10.25	6.42	2.83	.83	3.08	5.17	5.83	6.17
22	4.17	3.58	1.75	4.33	10.17	6.33	2.67	.75	3.08	5.17	5.58	6.17
23	4.17	3.58	1.75	4.42	9.75	6.17	2.50	.75	3.08	5.17	5.42	6.08
24	4.17	3.58	1.83	4.67	9.50	6.00	2.42	.67	3.08	5.17	5.25	6.00
25	4.08	3.58	1.83	5.00	9.50	6.00	2.33	.58	3.08	5.17	5.17	6.00
26	4.08	3.58	2.00	5.42	9.17	5.83	2.17	.50	3.08	5.17	5.00	5.92
27	4.00	3.58	2.17	5.58	9.00	5.83	2.00	.42	3.08	5.17	5.00	5.92
28	4.00	3.58	2.42	5.75	8.75	5.67	2.00	.42	3.08	5.17	5.00	5.92
29	3.92	.....	2.67	5.92	8.50	5.50	2.00	.42	3.08	5.17	5.00	5.83
30	3.92	.....	2.92	6.00	8.50	5.33	2.00	.33	3.08	5.08	5.00	5.83
31	3.92	.....	3.25	.....	8.50	.....	1.92	.33	.....	5.08	.....	5.83

March 9, 10, 11 and 12, waste gates opened; flashboards taken out. March 13, waste gates closed. April 6, waste gates opened. September 12, waste gates closed and flashboards put in.

Spokane River at Dam of the Washington Water Power Company, Spokane, Washington, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.75	5.67	3.75	6.50	10.08	12.33	6.75	3.42	1.50	1.25	2.42	3.50
2	5.75	5.50	3.75	6.83	10.00	12.33	6.67	3.33	1.42	1.25	2.50	3.58
3	5.67	5.33	3.92	7.00	9.83	12.33	6.50	3.25	1.42	1.25	2.58	3.58
4	5.58	5.17	3.92	7.00	9.75	12.25	6.33	3.25	1.42	1.25	2.67	3.58
5	5.50	5.00	3.92	7.08	9.58	12.25	6.17	3.17	1.42	1.25	2.67	3.58
6	5.42	5.00	3.92	7.08	9.50	12.25	6.00	3.08	1.42	1.25	2.75	3.58
7	5.33	4.92	3.92	7.08	9.50	12.08	5.92	3.08	1.33	1.25	2.75	3.50
8	5.25	4.92	4.00	7.08	9.42	11.92	5.75	3.00	1.33	1.25	2.83	3.50
9	5.17	4.83	4.00	7.08	9.42	11.67	5.58	2.92	1.33	1.25	2.92	3.50
10	5.00	4.83	4.00	7.25	9.42	11.33	5.42	2.83	1.33	1.83	3.00	3.50
11	4.83	4.75	4.00	7.25	9.33	10.00	5.33	2.75	1.33	1.83	3.17	3.50
12	4.67	4.67	4.00	7.50	9.25	9.83	5.25	2.67	1.33	1.83	3.25	3.50
13	4.67	4.50	4.00	7.83	9.25	9.67	5.17	2.58	1.25	1.83	3.25	3.33
14	4.75	4.50	4.08	8.17	9.17	9.42	5.08	2.50	1.25	1.75	3.25	3.33
15	5.17	4.50	4.08	8.50	9.08	9.17	4.92	2.42	1.25	1.75	3.25	3.25
16	6.25	4.33	4.08	8.83	9.08	9.00	4.83	2.33	1.25	1.75	3.25	3.17
17	7.00	4.33	4.08	8.92	9.33	8.83	4.67	2.25	1.25	1.75	3.25	3.08
18	7.50	4.17	4.17	8.92	9.58	8.75	4.50	2.17	1.25	1.75	3.25	3.08
19	7.58	4.00	4.17	8.83	9.92	8.67	4.33	2.08	1.25	1.67	3.17	3.00
20	7.58	3.92	4.33	8.75	10.08	8.50	4.25	2.00	1.25	1.67	3.08	3.00
21	7.50	3.83	4.42	8.67	10.17	8.33	4.08	1.92	1.25	1.67	3.00	2.92
22	7.33	3.83	4.58	8.67	10.33	8.25	3.92	1.83	1.25	1.67	3.00	2.92
23	7.00	3.83	4.67	8.67	10.50	8.08	3.83	1.75	1.25	1.67	3.00	2.83
24	6.83	3.75	4.67	8.83	10.75	7.92	3.75	1.75	1.25	1.67	3.00	2.83
25	6.67	3.75	4.67	9.08	11.00	7.75	3.75	1.67	1.25	1.67	3.08	2.75
26	6.42	3.75	4.75	9.42	11.33	7.58	3.67	1.58	1.25	1.83	3.08	2.75
27	6.25	3.75	4.92	9.58	11.67	7.42	3.67	1.58	1.25	2.00	3.08	2.75
28	6.08	3.75	5.08	9.92	12.00	7.25	3.58	1.58	1.25	2.17	3.17	2.67
29	6.00	.....	5.33	10.08	12.17	7.08	3.58	1.58	1.25	2.25	3.25	2.58
30	5.92	.....	5.67	10.08	12.17	6.92	3.50	1.50	1.25	2.33	3.42	2.50
31	5.83	.....	6.00	.....	12.42	.....	3.50	1.50	.....	2.33	.....	2.50

April 4, waste gates opened. Flashboards were carried out in high water of April and May. October 10, waste gates closed.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.42	3.50	4.83	4.17	7.00	6.00	3.33	1.75	2.75	3.00	3.00	3.50
2	2.42	3.42	4.83	4.33	7.17	6.00	3.25	1.75	2.75	3.00	3.00	3.50
3	2.33	3.42	4.92	4.42	7.17	5.83	3.00	1.75	2.75	3.00	3.00	3.50
4	2.33	3.25	5.00	4.50	7.25	5.75	3.00	1.75	2.75	3.00	3.00	3.50
5	2.25	3.17	5.08	4.67	7.25	5.67	3.00	1.67	2.83	3.00	3.00	3.50
6	2.25	3.17	5.08	4.67	7.33	5.58	3.00	1.67	2.83	3.00	3.08	3.50
7	2.25	3.08	5.00	4.75	7.50	5.58	2.83	1.58	2.83	3.00	3.08	3.50
8	2.25	3.00	4.83	4.75	7.50	5.50	2.83	1.58	2.92	3.00	3.17	3.50
9	2.25	2.92	4.83	4.75	7.58	5.33	2.75	1.58	3.00	3.00	3.17	3.50
10	2.33	2.83	4.75	4.83	7.67	5.00	2.67	1.58	3.00	3.00	3.17	3.50
11	2.33	2.83	4.67	4.92	7.67	5.00	2.67	1.58	3.00	3.00	3.17	3.50
12	2.42	2.75	4.50	5.00	7.50	5.00	2.58	1.50	3.08	3.00	3.17	3.58
13	2.67	2.75	4.50	5.00	7.33	5.00	2.58	1.50	3.17	3.00	3.17	3.58
14	3.08	2.67	4.42	5.17	7.00	5.00	2.50	1.42	3.00	3.00	3.17	3.67
15	3.50	2.58	4.42	5.25	7.00	4.67	2.50	1.42	3.00	3.00	3.17	3.67
16	4.00	2.58	4.42	5.33	6.83	4.50	2.42	1.42	3.00	3.00	3.17	3.67
17	4.33	2.58	4.25	5.50	6.75	4.33	2.42	1.42	3.00	3.00	3.17	3.67
18	4.33	2.58	4.17	5.67	6.75	4.25	2.42	1.33	3.00	3.00	3.17	3.67
19	4.33	2.50	4.17	5.67	6.67	4.17	2.33	1.25	3.00	3.00	3.17	3.67
20	4.33	2.50	4.00	5.75	6.58	4.08	2.33	1.17	3.00	3.00	3.17	3.67
21	4.42	2.50	4.00	5.75	6.58	4.00	2.25	1.08	3.00	3.00	3.17	3.67
22	4.25	2.50	3.92	5.75	6.58	3.83	2.25	1.00	3.00	3.00	3.17	3.67
23	4.25	2.67	3.83	5.83	6.58	3.83	2.17	.00	3.00	3.00	3.17	3.67
24	4.17	3.17	3.75	5.83	6.50	3.67	2.08	.00	3.00	3.00	3.17	3.67
25	4.17	3.58	3.75	6.00	6.33	3.58	2.00	.00	3.00	2.83	3.17	3.67
26	4.08	4.00	3.75	6.17	6.33	3.50	2.00	.00	3.00	2.83	3.17	3.67
27	4.00	4.33	3.75	6.50	6.17	3.50	2.00	.00	3.00	2.67	3.25	3.67
28	3.83	4.67	3.67	6.67	6.00	3.50	2.00	2.75	3.00	2.67	3.33	3.67
29	3.67	.....	3.67	6.92	6.00	3.50	1.92	2.75	3.00	2.83	3.33	3.75
30	3.67	.....	3.67	7.00	6.00	3.50	1.83	2.75	3.00	3.00	3.38	3.75
31	3.58	.....	4.00	.....	6.00	.....	1.75	2.75	.....	3.00	.....	3.75

August 23, waste gates opened. August 25, flashboards put in. August 28, one waste gate closed. September 5, other waste gate closed.

Spokane River at Spokane, Washington, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.75	5.00	6.33	7.67	7.33	8.42	8.00	3.25	1.83	1.42	1.40	4.70
2	3.75	5.00	6.17	7.50	7.42	8.67	7.83	3.25	1.83	1.42	1.50	4.60
3	3.75	5.00	6.17	7.50	7.42	8.67	7.67	3.17	1.83	1.33	1.50	4.60
4	3.75	5.00	6.00	7.50	7.50	8.75	7.50	3.08	1.75	1.33	1.50	4.70
5	3.83	5.00	6.00	7.33	7.50	8.75	7.33	3.00	1.75	1.33	1.55	5.20
6	3.83	5.00	6.00	7.17	7.58	8.83	7.08	3.00	1.75	1.33	1.55	5.50
7	3.83	5.00	6.00	6.83	7.58	8.92	6.33	2.92	1.67	1.33	1.60	5.60
8	3.83	5.00	6.00	6.83	7.67	8.83	6.58	2.83	1.67	1.33	1.60	5.85
9	3.92	5.00	6.00	6.67	7.67	8.75	6.33	2.83	1.67	1.25	1.65	6.10
10	3.92	5.00	6.00	6.67	7.75	8.75	6.17	2.75	1.67	1.25	1.65	6.30
11	3.92	5.00	6.00	6.67	7.75	8.75	6.00	2.75	1.67	1.25	1.70	6.50
12	3.92	5.00	6.00	6.67	7.75	8.75	5.83	2.67	1.58	1.25	1.80	6.60
13	4.00	5.00	6.00	6.75	7.75	8.67	5.67	2.67	1.58	1.25	1.80	6.90
14	4.00	5.00	6.00	6.92	7.75	8.67	5.50	2.58	1.58	1.25	1.80	7.20
15	4.00	5.00	6.00	6.92	7.75	8.58	5.25	2.58	1.58	1.25	2.10	7.50
16	4.00	5.00	6.00	7.33	7.75	8.58	5.00	2.50	1.58	1.25	3.10	7.60
17	4.00	5.17	5.83	7.50	7.75	8.58	4.75	2.42	1.58	1.25	4.35	7.60
18	4.00	5.17	5.83	7.58	7.67	8.58	4.58	2.42	1.58	1.25	5.30	7.50
19	4.17	5.17	5.67	7.58	7.67	8.58	4.42	2.33	1.58	1.25	6.00	7.40
20	4.17	5.33	5.67	7.58	7.58	8.58	4.25	2.33	1.58	1.25	6.30	7.20
21	4.33	5.33	5.67	7.50	7.50	8.50	4.17	2.25	1.58	1.25	6.30	7.10
22	4.42	5.33	5.83	7.33	7.50	8.50	4.00	2.17	1.58	1.17	6.35	7.00
23	4.50	5.33	6.00	7.17	7.50	8.50	4.00	2.17	1.50	1.17	6.35	6.70
24	4.50	5.33	6.33	7.08	7.50	8.50	3.83	2.08	1.50	1.17	6.20	6.60
25	4.67	5.42	7.00	7.00	7.58	8.50	3.67	2.08	1.50	a1.4	6.20	6.60
26	4.67	5.42	7.00	7.00	7.58	8.42	3.50	2.08	1.50	1.45	6.00	6.20
27	5.00	5.42	7.33	7.08	7.67	8.33	3.42	2.08	1.50	1.45	5.60	6.10
28	5.00	5.83	7.50	7.17	7.75	8.33	3.42	2.08	1.50	1.40	5.50	6.00
29	5.00	6.33	7.50	7.17	7.83	8.25	3.42	2.00	1.42	1.40	5.20	5.80
30	5.00	.....	7.67	7.25	8.00	8.17	3.33	1.92	1.42	1.40	5.00	5.60
31	5.00	.....	7.67	.....	8.17	.....	3.33	1.92	.....	1.40	.....	5.50

a New gage rod.

Umatilla River at Gibbon, Oregon.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.80	0.80	0.80	1.00	1.60	17	.....	0.80	0.80	0.80	4.00	2.40
2	.....	.75	.80	.80	1.00	1.60	18	.....	.80	.80	.85	3.80	2.30
3	.....	.75	.80	.80	1.00	1.60	19	.....	.80	.80	.85	3.45	2.25
4	.....	.90	.80	.80	1.10	2.05	20	.....	.80	.80	.85	3.00	2.20
5	.....	.95	.80	.80	1.10	2.45	21	.....	.80	.80	.85	2.70	2.10
6	.....	.85	.80	.80	1.00	2.40	22	0.85	.80	.80	.85	2.45	.....
7	.....	.85	.80	.80	1.00	2.30	23	.90	.80	.80	.80	2.30	2.05
8	.....	.85	.80	.80	2.30	2.20	24	.85	.80	.80	.80	2.10	2.00
9	.....	.85	.80	.80	1.90	2.20	25	.85	.80	.80	.80	2.05	1.90
10	.....	.85	.80	.90	2.20	2.30	26	.85	.80	.80	.80	1.95	.....
11	.....	.85	.90	.90	1.90	2.35	27	.85	.80	.80	.85	1.80	1.90
12	.....	.85	.90	.85	1.70	3.90	28	.85	.80	.80	.85	1.75	1.85
13	.....	.85	.85	.85	1.70	3.80	29	.85	.80	.80	.85	1.65	.....
14	.....	.85	.85	.85	3.20	3.20	30	.80	.80	.80	.90	1.60	1.80
15	.....	.85	.85	.85	4.10	2.80	31	.80	.90	.....	1.15	.....	.....
16	.....	.80	.85	.80	4.00	2.55							

Sacramento River at Redbluff, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	10.70	3.40	7.40	9.70	6.10	2.40	0.70	0.40	0.40	0.80	3.60
2	1.00	8.90	3.40	6.90	9.20	5.90	2.30	.70	.40	.40	.70	4.50
3	1.00	7.90	3.30	6.30	9.10	5.90	2.30	.70	.40	.40	.60	4.80
4	1.00	6.90	3.00	6.00	16.90	5.80	2.20	.60	.30	.40	.50	4.00
5	1.00	6.20	3.10	5.80	15.30	5.80	2.10	.60	.30	.40	.50	3.90
6	1.00	5.90	3.80	7.20	12.60	5.80	1.90	.60	.30	.30	.50	4.20
7	1.00	5.20	5.50	9.00	10.90	5.50	1.90	.50	.30	.30	.30	4.20
8	1.00	4.90	5.80	8.50	9.80	5.40	1.80	.50	.30	.30	.40	4.00
9	1.00	4.70	6.20	7.10	9.10	5.20	1.70	.50	.30	.30	.80	4.00
10	1.00	4.60	5.40	7.30	8.40	4.80	1.70	.50	.30	.30	.80	4.00
11	1.00	4.20	4.90	6.90	11.50	4.40	1.70	.50	.30	.30	.80	4.60
12	1.00	4.10	4.40	6.40	9.80	4.20	1.70	.50	.30	.30	.60	4.80
13	1.00	4.00	4.40	6.10	8.80	4.20	1.60	.40	.30	.30	.60	6.20
14	3.20	3.80	4.40	7.20	8.10	4.20	1.60	.40	.30	.30	.60	10.60
15	7.20	3.80	4.20	6.50	7.60	4.20	1.60	.40	.30	.30	.60	20.60
16	11.60	3.70	4.00	6.10	7.20	4.00	1.50	.40	.30	.30	1.20	14.40
17	23.50	3.40	4.00	5.70	6.80	3.90	1.50	.40	.30	.30	6.60	9.70
18	23.00	3.20	3.90	5.40	6.50	3.80	1.40	.40	.30	.30	5.20	9.20
19	22.30	3.10	3.90	5.50	6.20	3.60	1.30	.40	.30	.30	3.00	8.30
20	20.90	3.00	4.00	5.20	5.90	3.40	1.30	.40	.60	.30	3.40	7.30
21	22.40	2.90	6.60	5.10	5.80	3.30	1.30	.40	.60	.30	2.80	7.10
22	19.00	2.90	7.30	5.20	8.30	3.20	1.20	.40	.60	.30	2.90	7.10
23	14.80	2.90	9.90	5.50	8.10	3.10	1.20	.40	.50	.30	6.70	7.60
24	13.20	2.70	11.90	13.70	7.40	2.90	1.10	.40	.50	.30	12.50	9.40
25	19.60	2.70	13.10	15.30	6.60	2.90	1.10	.40	.50	.30	7.60	8.20
26	16.00	2.70	13.60	13.50	6.90	2.80	1.10	.40	.40	.30	3.90	10.40
27	24.10	2.70	15.50	12.70	6.80	2.70	1.00	.40	.40	1.30	3.20	11.60
28	19.90	2.80	18.00	11.40	6.90	2.60	1.00	.40	.40	.90	2.70	16.40
29	16.10	2.80	10.40	9.50	6.90	2.50	.90	.30	.40	.70	3.30	15.20
30	12.00	.....	8.50	9.20	6.80	2.50	.90	.30	.40	.70	3.30	10.80
31	9.40	.....	8.20	.....	6.50	.....	.80	.30	.....	.60	.....	9.40

Sacramento River at Jellys Ferry, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.70	13.60	7.90	11.30	12.90	10.30	6.90	5.90	5.70	5.60	5.90	6.80
2	5.70	12.90	7.80	10.80	13.30	10.30	6.80	5.90	5.70	5.60	5.80	6.90
3	5.70	11.90	7.90	10.40	13.40	10.10	6.70	5.90	5.60	5.60	5.80	7.00
4	5.70	11.20	7.70	10.10	21.20	10.10	6.70	5.80	5.60	5.60	5.70	7.00
5	5.70	10.60	7.70	10.20	19.00	10.10	6.60	5.80	5.60	5.60	5.70	7.00
6	5.70	10.10	8.10	12.50	16.50	10.00	6.60	5.80	5.60	5.60	5.70	7.10
7	5.70	9.80	9.60	11.50	15.10	9.80	6.60	5.80	5.60	5.50	5.70	7.10
8	5.70	9.40	10.30	11.50	14.00	9.70	6.50	5.80	5.60	5.50	5.70	7.00
9	5.70	9.10	10.60	11.30	13.10	9.40	6.50	5.80	5.60	5.50	5.70	6.90
10	5.70	9.00	9.70	10.60	12.40	9.20	6.50	5.80	5.60	5.50	6.10	6.80
11	5.70	8.70	9.30	10.40	14.50	8.90	6.40	5.70	5.60	5.50	5.90	6.70
12	5.70	8.60	9.00	10.20	13.70	8.80	6.40	5.70	5.60	5.50	5.80	7.20
13	5.70	8.30	8.90	11.20	12.90	8.60	6.40	5.70	5.60	5.50	5.80	11.20
14	5.90	8.20	8.80	10.50	12.40	8.60	6.30	5.70	5.60	5.50	5.70	16.30
15	11.20	8.10	8.50	10.10	11.90	8.40	6.30	5.70	5.50	5.50	5.70	24.00
16	19.00	7.90	8.50	9.80	11.30	8.30	6.30	5.70	5.50	5.50	8.00	16.70
17	27.70	7.80	8.40	9.60	10.90	8.20	6.30	5.70	5.50	5.50	11.70	13.20
18	23.70	7.70	8.30	9.60	10.70	8.00	6.20	5.70	5.50	5.50	9.00	11.10
19	22.80	7.60	8.20	9.60	10.50	8.00	6.20	5.70	5.50	5.50	7.50	9.90
20	27.80	7.50	8.80	9.30	10.20	7.80	6.20	5.70	5.70	5.50	8.50	9.30
21	26.50	7.50	10.60	9.40	16.00	7.70	6.10	5.70	5.70	5.50	7.40	8.80
22	21.80	7.50	11.80	9.40	12.60	7.60	6.10	5.70	5.70	5.50	10.50	8.40
23	19.50	7.40	14.10	10.00	12.30	7.50	6.10	5.70	5.70	5.50	10.60	8.00
24	18.30	7.40	16.30	18.50	11.60	7.40	6.00	5.60	5.70	5.50	15.40	7.90
25	21.90	7.30	17.00	16.90	11.00	7.30	6.00	5.60	5.70	5.50	11.40	7.70
26	20.50	7.30	17.80	15.80	10.90	7.20	6.00	5.60	5.70	5.60	9.30	7.60
27	29.70	7.50	19.10	14.20	10.90	7.10	6.00	5.60	5.60	6.50	8.30	10.00
28	24.30	8.10	16.40	13.10	10.80	7.10	6.00	5.60	5.60	5.90	7.70	15.20
29	19.80	7.90	14.60	12.90	11.00	7.00	6.00	5.60	5.60	5.70	7.20	15.60
30	17.00	.....	13.30	13.50	11.00	7.00	6.00	5.60	5.60	5.70	7.10	16.20
31	14.60	.....	12.20	.....	10.60	.....	5.90	5.70	.....	5.70	.....	16.40

Stanislaus River at Oakdale, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	3.90	3.70	5.40	5.60	9.90	5.00	2.80	3.60	2.80	2.40	3.00
2	2.10	3.80	3.40	5.30	5.60	10.50	4.80	2.70	3.20	2.80	2.40	3.00
3	2.10	3.70	3.50	5.20	5.60	9.10	4.70	2.70	2.80	2.30	2.40	3.00
4	2.10	3.60	3.40	5.00	5.70	8.20	4.60	2.40	2.60	2.50	2.40	3.00
5	2.10	3.60	3.30	4.80	6.30	8.30	4.70	2.70	2.50	2.20	2.40	2.90
6	2.10	3.40	3.30	5.60	5.80	8.60	5.70	2.60	2.50	2.20	2.30	2.90
7	2.10	3.30	3.30	5.60	5.40	8.70	5.00	2.50	2.50	2.20	2.30	2.90
8	2.10	3.30	3.30	5.00	5.30	9.10	4.70	2.50	2.70	2.20	2.40	2.80
9	2.10	3.20	3.30	4.90	5.20	9.90	4.90	2.50	2.50	2.20	3.80	2.80
10	2.10	3.20	3.30	5.10	5.00	9.50	4.60	2.50	2.50	2.30	3.30	2.80
11	2.10	3.20	3.20	4.90	5.20	8.60	4.60	2.50	2.50	2.30	2.80	2.80
12	2.00	3.20	3.50	5.00	5.70	9.10	4.30	2.50	2.40	2.20	2.60	2.80
13	2.20	3.10	3.60	5.10	5.40	8.60	4.10	2.50	2.40	2.20	2.50	4.50
14	2.20	3.10	3.70	7.60	5.90	9.00	3.80	2.50	2.30	2.20	2.50	4.00
15	2.20	3.10	3.90	6.30	6.10	8.80	3.70	2.50	2.30	2.20	2.50	3.50
16	2.30	3.10	4.00	5.70	5.90	8.20	3.60	2.40	2.30	2.20	2.50	3.50
17	3.70	3.10	4.80	5.40	6.00	8.40	3.50	2.40	2.30	2.20	2.50	3.30
18	5.90	3.10	4.70	5.10	6.00	7.90	3.70	2.40	2.30	2.20	2.60	3.10
19	6.60	3.20	4.50	4.90	5.70	7.00	3.60	2.40	2.30	2.20	2.70	3.00
20	8.30	3.20	4.90	4.70	5.60	6.90	3.50	2.40	2.30	2.20	2.70	3.00
21	8.30	3.20	6.10	4.70	5.90	7.60	3.40	2.50	2.40	2.20	2.90	2.90
22	7.20	3.20	6.60	4.90	6.20	7.50	3.30	2.50	2.40	2.20	3.10	2.90
23	5.50	3.20	6.40	5.10	6.80	6.80	3.30	2.40	2.40	2.20	3.00	2.90
24	4.90	3.20	6.10	9.30	7.10	7.10	3.20	2.60	2.40	2.20	6.70	2.80
25	4.50	3.20	6.30	9.50	7.90	6.50	3.10	2.50	2.40	2.20	5.50	2.80
26	4.40	3.30	7.80	7.60	9.00	6.00	3.10	2.40	2.40	2.20	4.00	2.90
27	7.70	3.40	11.00	6.40	9.60	6.00	3.10	2.30	2.40	2.50	3.60	3.30
28	7.20	3.50	7.30	5.90	10.40	6.00	3.00	2.20	2.40	2.60	3.40	3.40
29	5.00	3.80	6.40	5.70	11.50	5.90	3.00	2.20	2.30	2.40	3.10	3.30
30	4.50	.....	6.10	5.60	9.90	5.30	2.90	2.30	2.30	2.30	3.00	3.20
31	3.90	.....	5.70	.....	10.30	.....	2.80	5.10	.....	2.30	.....	4.30

Tuolumne River at Lagrange, California.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.50	5.80	.....	6.40	9.30	7.40	5.00	5.70	4.20	4.50	5.10
2	4.50	5.80	.....	6.50	9.30	7.20	5.00	5.20	4.20	4.50	5.20
3	4.50	5.60	.....	6.70	9.60	7.10	5.00	5.00	4.10	4.40	5.20
4	4.50	5.50	.....	6.90	9.20	7.20	4.90	4.90	4.10	4.30	5.20
5	4.50	5.50	.....	7.00	9.30	7.70	4.80	4.80	4.10	4.30	5.20
6	4.50	5.40	.....	6.80	9.20	7.70	4.80	4.70	4.10	4.30	5.10
7	4.50	5.40	.....	6.70	9.60	7.50	4.70	5.20	4.00	4.30	5.10
8	4.50	5.30	.....	6.70	9.20	7.30	4.70	5.10	4.00	4.30	5.00
9	4.50	5.30	.....	6.70	9.60	7.40	4.60	4.80	4.00	4.30	5.00
10	4.50	5.30	.....	6.60	9.20	7.40	4.50	4.70	4.00	6.40	5.00
11	4.50	5.30	.....	6.70	9.20	7.40	4.50	4.60	4.00	5.60	5.00
12	4.50	5.30	.....	6.80	9.20	7.10	4.50	4.50	4.00	5.20	5.00
13	4.50	5.30	.....	6.60	9.40	6.80	4.50	4.50	4.00	5.00	6.80
14	4.50	5.30	.....	6.50	9.20	6.50	4.50	4.40	3.90	4.90	6.10
15	4.50	5.30	7.00	6.60	9.50	6.30	4.50	4.30	3.90	4.80	5.70
16	4.90	5.30	6.90	6.40	9.50	6.30	4.50	4.20	3.90	4.70	5.60
17	5.60	5.30	6.60	6.40	9.20	6.40	4.40	4.20	3.90	4.80	5.40
18	8.50	5.30	6.50	6.60	9.20	6.20	4.40	4.20	3.90	5.10	5.20
19	7.20	5.30	6.40	6.30	9.10	6.10	4.40	4.10	3.90	5.20	5.10
20	8.30	5.30	6.30	6.50	9.80	5.90	4.50	4.10	3.90	5.20	5.10
21	8.10	5.30	6.50	6.80	8.50	5.90	4.50	4.30	3.90	5.50	5.10
22	7.30	5.30	6.40	7.00	8.60	5.80	4.50	4.30	3.90	5.30	5.00
23	7.00	5.30	6.30	6.90	8.60	5.70	4.50	4.50	3.90	5.30	5.00
24	6.70	5.30	8.40	7.10	8.10	5.60	4.40	4.50	3.90	7.90	5.00
25	6.10	5.30	9.10	7.80	8.20	5.40	4.40	4.40	3.90	7.00	4.90
26	5.60	5.30	8.50	8.50	8.00	5.70	4.40	4.30	3.90	6.20	4.90
27	8.90	5.30	8.10	8.90	7.90	5.60	4.30	4.30	4.20	5.70	5.10
28	7.60	5.30	7.90	9.20	7.90	5.40	4.30	4.30	4.50	5.50	5.40
29	7.50	5.30	7.20	10.20	8.10	5.30	4.30	4.30	4.40	5.30	5.50
30	7.10	.....	6.70	9.60	7.60	5.20	4.30	4.20	4.40	5.10	5.30
31	6.40	.....	.....	9.60	.....	5.10	6.50	.....	4.40	.....	5.70

Tuolumne River at Modesto, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	6.30	6.00	7.50	7.80	16.40	10.30	5.30	7.40	3.70	3.80	5.20
2	3.80	6.10	5.60	7.10	7.80	16.90	9.90	5.00	6.00	3.60	3.80	5.10
3	3.70	5.90	5.60	7.20	7.70	17.00	9.50	4.80	5.30	3.60	3.80	5.00
4	3.60	5.80	5.30	7.10	7.90	14.80	9.60	4.80	4.90	3.50	3.80	5.10
5	3.60	5.70	5.20	6.90	8.10	13.80	9.50	4.90	4.80	3.50	3.70	5.00
6	3.60	5.50	5.10	6.70	8.70	14.30	12.50	4.90	4.40	3.50	3.70	4.90
7	3.70	5.30	5.20	7.20	7.80	15.30	10.70	4.70	4.30	3.50	3.70	4.80
8	3.70	5.30	5.30	6.80	7.50	17.10	10.00	4.70	4.80	3.30	3.70	4.70
9	3.70	5.30	5.30	6.70	7.40	17.60	10.10	4.60	4.70	3.30	3.80	4.60
10	3.70	5.10	5.40	7.20	7.10	17.60	10.30	4.50	4.60	3.30	3.80	4.70
11	3.70	5.30	5.60	7.20	7.00	16.30	9.90	4.60	4.40	3.30	7.20	4.70
12	3.80	5.10	5.80	6.70	7.70	16.80	10.50	4.50	4.30	3.30	5.70	4.60
13	3.90	5.10	6.00	6.80	7.40	16.80	9.70	4.50	4.10	3.20	5.20	4.60
14	3.90	5.20	6.30	7.70	7.70	16.80	9.30	4.40	3.90	3.20	4.70	8.00
15	4.30	5.00	6.60	10.20	8.20	16.70	8.80	4.30	3.90	3.10	4.50	6.40
16	4.10	5.00	6.60	8.00	8.50	16.70	8.30	4.20	3.90	3.10	4.40	6.30
17	4.40	5.00	6.60	7.40	8.10	16.60	8.20	4.20	3.70	3.00	4.40	5.50
18	10.80	5.20	6.40	6.80	8.40	16.70	8.00	4.10	3.70	3.00	4.40	5.30
19	15.30	5.30	6.40	6.70	8.30	15.00	7.90	4.10	3.70	3.00	4.70	5.20
20	9.20	5.30	6.60	6.70	7.70	13.90	7.40	4.10	3.60	3.00	4.90	4.80
21	15.20	5.40	7.80	6.40	7.70	13.70	7.20	4.10	3.50	3.20	4.90	4.60
22	12.80	5.40	7.50	6.50	8.50	13.80	7.00	4.00	3.70	3.20	5.40	4.60
23	10.30	5.10	8.00	7.00	8.50	13.30	6.80	4.00	3.80	3.20	5.30	4.40
24	8.10	5.10	8.20	6.80	9.00	13.50	6.70	4.00	3.80	3.20	7.00	4.30
25	6.90	5.00	8.00	17.70	10.40	13.50	6.40	4.00	4.00	3.20	11.70	4.30
26	7.00	5.40	8.40	11.70	11.90	12.30	6.30	4.00	3.90	3.20	8.70	4.30
27	9.30	5.50	15.10	10.70	13.40	11.70	6.70	4.00	3.80	3.40	6.50	4.70
28	16.70	5.50	11.90	9.70	14.70	11.50	6.50	3.90	3.80	4.20	5.70	4.90
29	9.90	5.80	9.50	8.30	16.70	11.70	6.10	3.80	3.80	4.00	5.50	5.80
30	8.30	.....	8.40	8.40	17.60	11.00	5.80	3.80	3.70	3.80	5.30	5.50
31	6.80	.....	8.00	.....	16.10	.....	5.60	4.70	.....	3.80	.....	6.00

San Joaquin River at Herndon, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.60	3.70	3.80	4.60	4.50	9.20	5.90	3.50	3.40	2.30	2.80	2.80
2	2.50	3.70	3.90	4.40	4.60	9.60	5.70	3.40	3.30	2.30	2.70	2.70
3	2.50	3.60	3.80	4.20	4.70	9.70	5.50	3.50	3.20	2.30	2.70	2.70
4	2.50	3.60	3.70	4.10	4.90	9.10	5.40	3.50	3.10	2.50	2.70	2.70
5	2.60	3.40	3.50	4.10	4.90	9.10	6.00	3.40	3.00	2.50	2.70	2.70
6	2.70	3.30	3.40	4.00	5.30	8.90	6.60	3.40	3.00	2.40	2.70	2.80
7	2.70	3.30	3.40	4.20	4.80	8.80	6.10	3.30	2.80	2.40	2.70	3.00
8	2.60	3.20	3.40	4.00	4.50	8.80	5.80	3.30	3.20	2.30	2.70	2.90
9	2.60	3.20	3.50	4.00	4.50	8.70	5.70	3.30	3.30	2.30	2.70	2.80
10	2.60	3.30	3.50	4.00	4.30	8.90	5.80	3.30	3.10	2.30	2.70	2.80
11	2.60	3.30	3.60	4.30	4.30	8.70	6.90	3.30	3.10	2.30	3.30	2.80
12	2.60	3.30	3.70	4.20	4.60	8.00	6.10	3.30	2.90	2.30	3.20	2.80
13	2.60	3.30	3.80	4.10	4.60	7.80	5.90	3.30	2.90	2.30	3.00	2.80
14	2.60	3.30	3.80	4.20	4.90	8.80	5.60	3.30	2.80	2.30	2.90	3.30
15	2.60	3.30	3.80	4.10	5.20	8.80	5.20	3.30	2.70	2.30	2.90	3.80
16	2.80	3.30	4.00	4.30	5.20	8.70	4.80	3.30	2.70	2.30	2.80	3.50
17	3.20	3.30	4.00	5.60	5.00	8.90	4.70	3.30	2.70	2.30	2.80	3.30
18	4.20	3.80	4.00	4.70	5.20	8.70	5.20	3.80	2.70	2.30	2.80	3.10
19	8.50	3.30	4.00	4.20	5.00	8.00	4.80	3.50	2.70	2.30	2.80	3.00
20	5.00	3.30	4.00	4.00	4.80	7.80	4.70	3.50	2.60	2.30	2.80	3.00
21	8.00	3.30	4.30	4.00	5.00	8.00	4.50	3.40	2.50	2.30	2.80	2.90
22	6.50	3.30	4.30	4.00	5.00	7.70	4.40	3.30	2.50	2.40	2.70	2.80
23	4.80	3.30	4.70	3.90	5.10	7.30	4.60	3.30	2.50	2.40	2.80	2.80
24	4.30	3.40	4.80	3.90	5.60	7.00	4.50	3.30	2.50	2.30	3.00	2.70
25	4.00	3.40	4.70	4.00	6.10	7.00	4.50	3.30	2.50	2.30	4.20	2.70
26	3.80	3.50	4.80	5.90	7.10	6.60	4.50	3.10	2.60	2.30	3.70	2.80
27	4.00	3.50	8.30	5.40	7.10	6.40	4.40	3.00	2.50	2.50	3.70	2.80
28	5.00	3.50	5.90	4.80	8.10	6.30	4.00	3.00	2.50	2.50	3.20	3.00
29	4.30	3.80	5.40	4.60	10.20	6.30	3.90	3.00	2.30	3.00	3.00	3.10
30	4.00	.....	5.00	4.70	9.30	6.30	3.70	3.00	3.30	3.00	2.90	3.10
31	3.80	.....	4.70	.....	8.50	.....	3.70	3.00	.....	2.80	.....	3.00

Kings River at Red Mountain, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	*4.00*	5.30	5.30	*5.00*	*6.00*	*10.40*	*7.90*	*5.60*	*4.50*	*3.90*	4.20	*4.30*
2	*4.00*	5.10	5.10	*5.20*	*6.00*	*10.40*	7.60	*5.50*	*4.40*	3.90	*4.20*	4.30
3	*4.00*	5.10	5.30	*5.30*	*6.00*	*10.40*	*8.00*	5.50	*4.40*	*3.90*	*4.20*	*4.30*
4	*4.00*	5.10	5.30	*5.40*	*7.00*	*10.40*	*8.40*	*5.30*	4.40	*3.80*	*4.10*	*4.30*
5	*4.00*	5.00	5.30	*5.50*	*7.00*	*10.40*	8.70	*5.20*	*4.40*	*3.90*	4.10	*4.30*
6	*4.00*	4.90	5.30	*6.00*	*8.00*	*10.40*	*8.70*	*5.10*	*4.50*	*3.80*	*4.10*	4.30
7	*4.00*	4.90	5.20	*6.50*	*8.00*	10.40	*8.70*	5.00	4.50	*3.80*	*4.00*	*4.30*
8	*4.00*	4.90	5.30	*7.00*	*7.00*	*10.40*	*8.70*	*5.00*	*4.50*	3.80	4.00	*4.30*
9	*4.00*	4.90	5.40	*7.50*	*6.00*	*10.40*	*8.60*	4.90	*4.50*	*3.80*	*4.30*	*4.30*
10	*4.00*	4.80	5.50	*8.00*	*5.50*	*11.40*	*8.60*	*4.90*	*4.50*	*3.80*	*4.60*	*4.30*
11	*4.00*	4.80	5.70	*7.00*	*5.50*	11.40	8.60	*4.90*	4.50	3.80	4.90	*4.30*
12	4.00	4.80	5.90	6.40	*5.50*	10.90	8.20	*4.80*	*4.40*	*3.80*	4.60	4.30
13	4.00	4.80	6.00	6.90	*5.50*	*10.70*	*7.80*	*4.80*	4.30	*3.80*	*4.50*	4.20
14	4.00	4.80	6.00	7.50	*7.00*	10.50	7.30	4.80	*4.30*	*3.80*	*4.40*	*4.20*
15	4.00	4.80	5.90	7.10	*7.00*	*10.60*	*7.20*	*4.80*	*4.20*	3.80	4.30	*4.30*
16	4.30	4.90	5.80	*6.00*	*8.00*	*10.80*	*7.10*	*4.80*	*4.10*	*3.80*	*4.30*	*4.40*
17	4.90	4.90	5.80	*5.00*	*8.00*	*10.90*	7.00	4.80	4.10	*3.80*	*4.20*	4.40
18	9.20	4.90	6.00	*4.00*	*8.00*	*11.00*	*6.90*	*4.90*	*4.10*	*3.80*	*4.10*	*4.40*
19	7.00	4.90	6.00	*4.50*	*8.00*	*10.70*	*6.70*	*4.90*	*4.00*	*3.80*	4.10	*4.30*
20	6.40	5.00	6.30	*5.00*	*8.00*	*10.40*	6.50	*5.00*	4.00	*3.80*	*4.10*	4.20
21	9.80	5.00	6.40	*5.00*	*8.00*	10.10	6.50	5.00	*4.00*	3.80	*4.10*	*4.20*
22	7.10	4.90	6.40	*5.00*	*8.00*	*9.80*	8.50	*5.00*	*4.10*	*3.80*	4.10	*4.20*
23	6.40	4.90	6.70	*5.50*	*8.00*	*9.50*	*7.50*	4.80	*4.20*	*3.80*	*4.50*	4.20
24	5.90	4.90	6.90	*6.00*	*8.00*	*9.20*	*7.00*	*4.80*	4.20	*3.80*	*5.00*	*4.20*
25	5.70	5.10	8.80	*6.50*	*9.00*	8.90	*6.50*	*4.70*	*4.20*	3.80	5.40	*4.20*
26	5.70	5.10	*8.00*	*8.00*	*10.00*	*8.80*	*6.30*	*4.70*	*4.10*	*3.90*	4.80	*4.20*
27	5.50	5.10	7.20	*8.00*	*11.00*	*8.80*	6.20	*4.70*	4.10	*4.30*	*4.60*	4.20
28	6.00	5.50	*6.50*	*7.50*	*12.00*	8.80	*6.00*	*4.60*	*4.10*	4.30	*4.40*	*4.20*
29	5.70	5.50	*6.00*	*6.00*	*12.00*	*8.50*	*5.80*	4.60	*4.00*	*4.30*	4.20	*4.20*
30	5.40	.....	*5.50*	*6.00*	*11.00*	*8.20*	5.60	*4.60*	*4.00*	*4.30*	*4.20*	*4.30*
31	5.30	.....	*5.00*	.....	*10.00*	.....	*5.60*	4.50	.....	*4.30*	.....	4.30

Figures in italics are estimated from observations taken at Kingsburg, on the same river, and from other rod readings at Red Mountain.

Kings River at Kingsburg, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	5.20	4.10	4.30	4.00	10.30	6.50	3.50	3.70	4.40	4.40	4.40
2	2.20	5.10	4.30	4.10	4.40	10.30	6.00	3.30	3.70	4.50	4.30	4.50
3	2.20	5.00	5.10	4.00	4.80	9.90	6.10	3.30	3.70	4.50	4.30	4.50
4	2.20	4.80	5.10	3.90	5.40	9.30	6.00	3.30	3.70	4.50	4.20	4.50
5	2.20	4.60	5.10	3.80	5.90	9.30	6.70	3.30	3.70	4.50	4.00	4.50
6	2.20	4.60	4.60	3.30	6.50	9.30	7.10	3.30	3.70	4.60	3.80	4.50
7	2.20	4.50	3.60	3.10	5.90	9.60	6.70	3.20	3.70	4.60	3.80	4.50
8	2.20	4.20	3.10	3.00	5.00	10.30	6.50	3.20	3.70	4.60	3.70	4.40
9	2.20	3.80	2.90	3.00	4.60	10.50	6.30	3.20	3.80	4.50	3.70	4.30
10	2.20	3.70	2.80	6.00	4.20	10.70	6.40	3.20	3.80	4.50	3.60	4.30
11	2.10	3.60	2.90	5.70	3.70	9.90	6.70	3.30	3.70	4.50	4.00	4.40
12	2.10	3.50	3.10	4.60	4.00	10.00	6.50	3.60	3.80	4.50	4.90	4.50
13	2.10	3.30	3.50	4.00	4.70	9.90	6.30	3.80	3.70	4.60	4.50	4.30
14	2.20	3.10	3.60	3.00	5.30	9.60	6.10	3.80	3.60	4.50	4.30	4.80
15	2.20	2.80	3.80	6.10	6.20	9.50	5.90	3.80	3.60	4.50	4.00	3.50
16	2.20	2.80	3.60	4.60	6.30	9.30	5.50	3.70	3.50	4.50	3.90	3.20
17	3.30	2.70	3.20	3.70	5.80	9.80	5.50	3.70	3.50	4.30	3.70	3.30
18	5.40	3.00	3.30	3.10	6.20	9.30	5.60	3.70	3.50	3.80	3.50	3.70
19	8.70	3.00	3.70	3.00	6.20	8.70	5.60	3.80	3.50	3.30	3.50	4.00
20	6.50	3.00	3.70	4.30	5.90	8.40	5.00	3.90	3.50	3.30	3.70	4.00
21	8.00	2.90	4.20	4.20	6.20	8.50	4.70	3.80	3.50	3.30	3.70	4.10
22	7.70	2.90	4.50	4.00	6.40	8.00	4.60	3.80	3.50	3.30	3.60	4.10
23	6.50	2.60	4.50	3.40	6.10	7.70	4.30	3.70	3.40	3.10	3.70	4.00
24	6.20	2.40	5.00	3.30	6.60	7.20	6.40	3.70	3.40	3.10	3.80	4.00
25	5.90	2.50	5.80	5.00	7.40	7.00	5.70	3.70	3.40	3.00	4.70	3.80
26	5.90	2.50	5.50	7.20	8.40	6.80	5.40	3.70	3.40	3.00	5.30	3.80
27	5.80	2.50	8.00	6.60	9.30	6.70	4.90	3.70	4.10	3.50	4.70	3.90
28	6.10	2.60	6.30	5.70	10.30	6.70	4.30	3.70	4.30	4.00	4.60	4.20
29	6.10	3.00	5.80	4.70	11.10	6.70	3.90	3.70	4.30	4.50	4.50	4.40
30	5.80	.....	5.20	4.80	10.20	6.50	3.70	3.70	4.30	4.40	4.40	4.30
31	5.50	.....	4.80	.....	9.80	.....	3.60	3.70	.....	4.40	.....	4.20

Santa Ana River at Warmsprings, California.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	14.50	16.20	16.00	15.50	12.00	12.00
2	14.50	15.30	16.20	16.50	12.00	12.00
3	15.00	16.00	16.00	15.30	12.00	12.30
4	15.00	15.50	14.50	15.00	12.00	12.30
5	15.00	15.70	14.50	13.70	12.00	12.30
6	15.00	15.30	12.50	13.50	12.00	12.30
7	14.00	16.70	15.50	14.50	11.50	12.30
8	14.00	15.30	15.50	14.50	11.50	12.30
9	15.50	15.30	15.30	14.00	11.50	12.30
10	15.70	15.30	15.20	15.00	11.50	12.30
11	15.50	15.50	11.00	15.50	11.50	12.30
12	16.30	15.20	11.30	15.00	11.70	12.30
13	16.50	15.50	13.50	14.00	11.50	12.30
14	14.50	15.20	15.00	14.00	11.50	12.30
15	15.50	15.20	15.00	14.20	11.50	12.30
16	15.00	a 15.20	16.00	13.00	11.50	12.50
17	16.00	13.20	16.50	14.00	11.50	12.50
18	16.00	13.00	16.30	14.30	11.50	12.50
19	16.00	16.00	16.00	14.30	11.50	12.50
20	16.00	14.00	15.50	14.30	11.50	12.50
21	16.00	14.20	14.50	12.70	11.70	12.50
22	16.50	14.30	14.30	13.50	11.80	12.50
23	16.50	12.00	13.50	13.30	12.00	12.20
24	16.50	12.20	13.30	13.00	12.00	12.20
25	15.50	12.70	14.00	13.00	14.30	12.30
26	14.00	13.20	14.70	13.00	12.50	12.00
27	15.00	13.20	13.00	a 21.00	12.50	12.00
28	15.00	14.30	13.50	14.00	12.30	13.00
29	16.50	16.00	14.00	14.00	12.30	13.00
30	15.70	16.00	15.00	14.00	12.30	12.70
31	16.20	14.20	.....	14.00	.....	12.30

a On August 16 the discharge gates of Bear Valley Dam were temporarily closed on account of a storm, and on October 27 they were closed for the season. Discharge of Santa Ana Canal is not included in the above statement.

CURRENT METERS RATED IN 1896.

No. 16. Large Haskell meter. Property of B. M. Hall, Atlanta, Ga. Last rated July 14, 1896, and returned to B. M. Hall July 17, 1896.

No. 25. Small Haskell meter. Returned to office December 12, 1895; rated July 27, 1896, by A. P. Davis at the Kensington station, Md.; sent to Prof. A. L. Lamb, Port Deposit, Md., November 12, 1896.

No. 27. Small Haskell meter. Rated June 27, 1896, by A. P. Davis at Kensington station, Md.; sent to Oskar Huber, Spokane, Wash., October 20, 1896.

No. 63. Large Price electric meter. Rated by J. B. Lippincott and C. C. Babb June 18, 1896, at rating station, Kern County, Cal.; transferred by J. B. Lippincott to C. C. Babb and used by him during summer of 1896; last rated December 10, 1896, by C. C. Babb at Kensington station, Md.

No. 67. Large Price electric meter. Purchased July 2, 1896; rated July 14; sent to W. Richins, Arizona, July 27, 1896; was damaged in shipment and returned to this office for repairs August 26, 1896; repaired and rated September 25, at Kensington, Md. Sent to J. B. Lippincott, Los Angeles, Cal. Sepember 26, 1896.

No. 68. Large Price electric meter. Purchased July 2, 1896; rated July 28, at Kensington station, Md., and used during the season of 1896 by E. G. Paul.

No. 69. Large Price electric meter. Purchased July 20, 1896; rated July 28, 1896, by E. G. Paul at Kensington station, Md., and sent August 26, 1896, to W. Richins for use in Queen Creek, Ariz.

No. 70. Large Price electric meter. Received December 15, 1896, to replace No. 62, large Price electric meter, which was destroyed by fire while in charge of a transportation company. Rated December 15, 1896, by E. G. Paul at Kensington station, Md.

No. 91. Small Price electric meter. Purchased November 12, 1896; rated December 10, 1896, at Kensington station, Md., by C. C. Babb and E. G. Paul.

Rating tables made in 1896 for current meters.

Revolutions per second.	Velocities in feet per second.										
	No. 16.	No. 25 H. P.	No. 25 L. P.	No. 27 H. P.	No. 27 L. P.	No. 63.	No. 67.	No. 68.	No. 69.	No. 70.	No. 91.
0.00	0.27	0.67	1.01	0.63	0.70	0.40	0.25	0.20	0.25	0.20	0.10
.10	.33	.78	1.12	.70	.83	.63	.45	.51	.53	.35	.25
.20	.42	.80	1.23	.76	.96	.91	.72	.81	.81	.65	.51
.30	.49	.86	1.35	.82	1.09	1.19	1.00	1.12	1.09	.97	.77
.40	.57	.93	1.46	.90	1.27	1.47	1.30	1.42	1.37	1.26	1.03
.50	.69	1.03	1.58	.99	1.44	1.75	1.60	1.73	1.65	1.55	1.29
.60	.80	1.13	1.72	1.07	1.61	2.03	1.90	2.04	1.93	1.85	1.55
.70	.92	1.23	1.87	1.15	1.79	2.31	2.19	2.36	2.21	2.14	1.81
.80	1.04	1.34	2.01	1.25	1.98	2.59	2.48	2.67	2.49	2.44	2.07
.90	1.16	1.44	2.16	1.33	2.19	2.87	2.77	2.98	2.77	2.73	2.33
1.00	1.28	1.55	2.33	1.42	2.40	3.15	3.06	3.29	3.04	3.03	2.59
1.10	1.40	1.65	2.50	1.51	2.62	3.43	3.35	3.59	3.32	3.33	2.85
1.20	1.52	1.75	2.68	1.60	2.83	3.71	3.64	3.90	3.60	3.62	3.11
1.30	1.64	1.85	2.86	1.69	3.04	3.99	3.93	4.19	3.88	3.92	3.37
1.40	1.76	1.95	3.03	1.77	3.25	4.27	4.23	4.48	4.16	4.22	3.63
1.50	1.88	2.05	3.19	1.86	3.46	4.55	4.53	4.77	4.44	4.51	3.90
1.60	2.00	2.15	3.36	1.97	3.67	4.83	4.82	5.06	4.72	4.81	4.16
1.70	2.12	2.26	3.54	2.07	3.88	5.11	5.11	5.36	5.00	5.11	4.42
1.80	2.24	2.36	3.72	2.18	4.09	5.39	5.40	5.65	5.28	5.40	4.68
1.90	2.36	2.48	3.90	2.29	4.30	5.67	5.70	5.94	5.56	5.70	4.94
2.00	2.48	2.59	4.07	2.39	4.51	5.95	6.00	6.23	5.84	6.00	5.20
2.10	2.60	2.71	4.24	2.49	4.72	6.23	6.29	6.52	6.12	6.29	5.63
2.20	2.72	2.83	4.42	2.60	4.93	6.51	6.58	6.81	6.40	6.58	6.07
2.30	2.84	2.95	4.59	2.71	5.14	6.79	6.87	7.10	6.68	6.88	6.50
2.40	2.96	3.07	4.77	2.81	5.35	7.07	7.17	7.39	6.96	7.17	7.60
2.50	3.08	3.19	4.95	2.92	5.56	7.35	7.47	7.68	7.24	7.46	8.80
2.60	3.20	3.31	5.13	3.02	5.77	7.63	7.77	7.97	7.52	7.76	10.30
2.70	3.32	3.43	5.31	3.12	5.98	7.91	8.06	8.26	7.80	8.05	11.60
2.80	3.44	3.55	5.49	3.23	6.18	8.19	8.36	8.55	8.08	8.34	.....
2.90	3.56	3.67	5.67	3.34	6.39	8.47	8.65	8.85	8.37	8.63	.....
3.00	3.68	3.79	5.85	3.44	6.61	8.75	8.95	9.13	8.65	8.92	.....
3.10	3.80	3.91	6.02	3.56	6.82	9.03	9.24	9.42	8.94	9.21	.....
3.20	3.92	4.03	6.20	3.66	7.03	9.31	9.53	9.71	9.22	9.50	.....
3.30	4.04	4.15	6.38	3.77	7.24	9.59	9.82	10.00	9.51	9.80	.....
3.40	4.16	4.26	6.56	3.88	7.45	9.87	10.11	10.29	9.80	10.10	.....
3.50	4.28	4.38	6.74	3.98	7.66	10.15	10.41	10.59	10.10	10.39	.....
3.60	4.40	4.50	6.92	4.09	7.87	10.43	10.70	10.89	.....	10.68	.....
3.70	4.52	4.62	7.09	4.19	8.08	10.71	10.99	.....	.....	10.98	.....
3.80	4.64	4.74	7.27	4.30	.....	10.99	11.28	.....	.....	11.28	.....
3.90	4.76	4.86	7.44	4.40	.....	11.27	11.57	.....	.....	11.57	.....
4.00	4.88	4.98	7.61	4.51	.....	11.55	11.87	.....	.....	11.86	.....
4.10	5.00	5.10	7.79	4.62	.....	11.83	12.17	.....	.....	.....	.....
4.20	5.12	5.22	7.97	4.73	.....	12.11	12.46	.....	.....	.....	.....
4.30	5.24	5.34	8.14	4.83	.....	12.39	12.76	.....	.....	.....	.....
4.40	5.36	5.46	8.31	4.93	.....	12.67	13.05	.....	.....	.....	.....
4.50	5.48	5.58	8.49	5.04	.....	12.95	13.35	.....	.....	.....	.....
4.60	5.60	5.70	8.67	5.14	.....	13.23	.....	.....	.....	.....	.....
4.70	5.72	5.81	8.85	5.24	.....	13.51	.....	.....	.....	.....	.....
4.80	5.84	5.92	9.03	5.34	.....	13.79	.....	.....	.....	.....	.....
4.90	5.96	6.04	.....	5.45	.....	14.07	.....	.....	.....	.....	.....
5.00	6.08	6.16	.....	5.55	.....	14.35	.....	.....	.....	.....	.....

DRAINAGE AREA MEASUREMENTS.[1]

	Square miles.
American Fork near American Fork, Utah	66
Animas River at Durango, Colorado	812
Arkansas River, East Fork, near Leadville, Colorado	44
Arkansas River, Lake Fork, near Leadville, Colorado	21
Arkansas River, Tennessee Fork	44
Arkansas River at Granite, Colorado	425
Arkansas River at Salida (above South Fork)	1,160
Arkansas River at Canyon City, Colorado	3,060
Arkansas River at Swallows, Colorado	4,300
Arkansas River at Pueblo, Colorado	4,600
Arkansas River at La Junta, Colorado (including Fountain Creek drainage, 1,011 square miles)	12,200
Arkansas River at railroad bridge above Holly, Colorado (including Animas River, 7,333 square miles)	23,500
Arkansas River at Colorado-Kansas State line	24,600
Arkansas River at Hutchinson, Kansas	34,000
Bear Creek at Morrison, Colorado	170
Bear River at Battle Creek, Idaho	4,500
Bear River at Collinston, Utah	6,000
Bear River at Soda Springs, Idaho	3,940
Black Warrior River at Tuscaloosa, Alabama	4,900
Blacks Fork, 3 miles west of Granger, Wyoming	1,747
Boise River at Boise, Idaho	2,450
Boise River at Caldwell, Idaho	3,360
Boulder Creek, South, at South Boulder Canyon, near Marshall, Colorado	125
Boulder Creek, North, at Boulder, Colorado	179
Boulder Creek, near Boulder, Colorado	102
Blue River in Kansas	2,450
Blue River in Nebraska	7,040
	9,490
Broad River at Gaffney, South Carolina	1,435
Broad River at Alston, South Carolina	4,609
Bruneau River at Grand View, Idaho	1,800
Cache la Poudre River above Fort Collins, Colorado	1,060
Caliente Creek:	
Tehachapi Creek	108
Caliente Creek proper	219
Basin Creek	96
	423
Canadian River in Kansas	5,110
Canadian River in New Mexico	16,900
Canadian River in Texas	18,620
	40,630
Cape Fear River at Fayetteville, North Carolina	4,493
Carson River, east, at Rodenbahs, Nevada	414
Carson River, west, at Woodford, California	70
Carson River near Empire, Nevada	894
Catawba River at Catawba, South Carolina	3,492
Catawba River at Fort Mill, South Carolina	2,987
Chama River at Abiquiu, New Mexico	2,300
Chattahoochee at Oakdale, Georgia	1,560
Chattahoochee at Westpoint, Georgia	3,300
Chowchilla Creek above sec. 1, T. 9 S., R. 18 E.	268
Cimarron at Arkalon, Kansas	5,200
Clear Creek, 4 miles west of Buffalo, Wyoming	118
Clear Creek near Granite, Colorado	72
Colorado River in Arizona[2]	56,182
Colorado River in California	8,610
Colorado River in Colorado	5,490
Colorado River in Nevada	3,200
Colorado River in New Mexico	19,000
Colorado River in Utah	21,633
	114,115

[1] A number of the drainage areas not given in this table are to be found on pages 107 to 110 of the Eleventh Annual Report, Part II.

[2] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

	Square miles.	
Colorado River at Yuma, Arizona		225,049
Columbia River in Oregon[1]		24,093
Columbia River in Idaho[1]	7,880	
Columbia River in Montana	25,000	
Columbia River in Washington	26,160	
		59,040
Connecticut River at Hartford, Connecticut		10,234
Coosa River at Riverside, Alabama		6,850
Coosawattee River at Carters, Georgia		532
Cottonwood Creek, South Fork, near Buena Vista, Colorado		28
Cottonwood Creek, Middle Fork, near Buena Vista, Colorado		37
Dan River at Clarksville, Virginia		3,798
Dolores River at Dolores, Colorado		562
Elkhorn River at Norfolk, Nebraska		2,474
Etowah River at Canton, Georgia		573
Falls River, 5 miles above mouth, Idaho		594
Fort Tejon Creek, including Cuddy Creek and Castac Lake (upper basin, 56)		93
French Broad River at Asheville, North Carolina		987
Frenchman River at Wauneta, Nebraska		989
Frenchman River at Palisade, Nebraska		1,032
Gallatin River at Logan, Montana		1,620
Gila River at Buttes, Arizona		13,750
Gila River, including small lost basins, in Arizona[1]	56,838	
Gila River, including small lost basins, in New Mexico	14,300	
		71,138
Goose Creek, Big, at Sheridan, Wyoming, below mouth of Little Goose Creek		320
Goose Creek, Little, at Sheridan, Wyoming		128
Grand River at Glenwood Springs, Colorado		5,838
Grand River at Grand Junction, above Gunnison River, Colorado		8,644
Grand River at Grand Junction, below Gunnison River (including, above Uncompahgre, 497 square miles, and Gunnison, at mouth, 7,935 square miles)		16,579
Grand River in Colorado[1]	22,294	
Grand River in Utah	3,873	
		26,167
Great Basin in California[1]	47,240	
Great Basin in Idaho	3,420	
Great Basin in Nevada	102,220	
Great Basin in Oregon	18,950	
Great Basin in Utah	43,548	
Great Basin in Wyoming	1,494	
		216,872
Green River at Green River, Wyoming		7,450
Green River at Blake, Utah		38,200
Green River in Colorado[1]	10,332	
Green River in Utah	15,916	
Green River in Wyoming	20,977	
		47,225
Greenbrier River at Alderson, West Virginia		1,344
Greenbrier River at mouth, West Virginia		1,575
Gunnison River at Grand Junction, Colorado		7,935
Gunpowder River at Baltimore Conduit, Maryland		294
Henry Fork, 1 mile above mouth of Falls River, Idaho		931
Hiwassee River at Murphy, North Carolina		410
Humboldt River at Elko, Nevada		2,840
Humboldt River at Battle Mountain, Nevada		7,800
Humboldt River at Golconda, Nevada		10,780
Humboldt River (including Grassy Valley) at Oreana, Nevada		14,967
Humboldt River, South Fork, at Masons Ranch, Nevada		536
James River, South, at mouth, Virginia		116
James River, North, at East Glasgow, Virginia		831
James River at Buchanan, Virginia		2,058
James River at Balcony Falls, Virginia		3,027
Jefferson River at Sappington, Montana		8,984
Jefferson River at Three Forks, Montana		9,400
Jones Falls at Baltimore Conduit, Maryland		38
Kansas River at Lecompton, Kansas		58,554
Kansas River at Lawrence, Kansas		59,841

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

	Square miles.	
Kansas River in Kansas	34,526	
Kansas River in Nebraska	17,455	
Kansas River in Colorado	9,459	
		61,440
Kaweah River above sec. 3, T. 18 S., R. 27 E., California		619
Kern River at first point of measurement above Bakersfield, California, including—		
North Fork	1,115	
South Fork	1,050	
Lower Basin	180	
		2,345
Kings River		1,742
Laramie River above Woods Landing, Wyoming (in Colorado, 343)		435
Laramie River at Uva, Wyoming (including in Colorado, 428)		3,179
Laramie River at mouth at Fort Laramie (not including 500 square miles of lost drainage to James Lake, Cooper Lake, etc.)		4,076
Logan River at Logan, Utah		218
Loup River, Middle, at St. Paul, Nebraska		6,849
Loup River, North, at St. Paul, Nebraska		4,024
Loup River at Columbus, Nebraska		13,542
Madison River at Redbluff, Montana		2,085
Madison River at Threeforks, Montana		2,402
Malad River at Taponis, Idaho		2,190
Malheur River at Vale, Oregon		9,900
Medicine River at Kiowa, Kansas		1,300
Merced River above Merced Falls, California		1,076
Middle Creek near Bozeman, Montana		55
Mississippi River at St. Paul, Minnesota (Minnesota River, 16,350)		36,085
Missouri River at Townsend, Montana		14,500
Missouri River at Canyon Ferry, Montana		15,036
Missouri River at Craig, Montana		17,615
Missouri River above Yellowstone, in Montana[1]	81,018	
Missouri River above Yellowstone, in Wyoming	760	
		81,778
Monocacy River at Frederick, Maryland		665
Nantahalah River at mouth, North Carolina		193
Natches River at North Yakima, Washington		1,000
Neosho River at Iola, Kansas		3,670
Neuse River at Selma, North Carolina		1,175
New River at Greenbrier River, West Virginia		4,523
New River at Hinton, West Virginia		5,600
New River at Fayette, West Virginia		6,200
North Platte River above Sweetwater (including in Colorado, 1696)		7,668
North Platte River above Douglas, Wyoming		14,255
North Platte River above Orin Junction, Wyoming		14,828
North Platte River above Fort Laramie, Wyoming		16,416
North Platte River below Laramie River, Wyoming		20,492
North Platte River in Wyoming and Colorado		23,643
North Platte River at Camp Clark, Nebraska		24,225
North Platte River to North Platte, Nebraska		28,517
Ocmulgee River at Macon, Georgia		2,425
Oconee River at Carey, Georgia		1,346
Ogden River at Powder Mills, Utah		360
Oostenaula River at Resaca, Georgia		1,527
Owyhee River at Ontario, Oregon		9,875
Patapsco River at Woodstock, Maryland		251
Patuxent River at Laurel, Maryland		137
Payette River at Payette, Idaho		3,565
Piedras River at Arboles, Colorado		650
Platte River at North Platte:		
North Platte River	28,517	
South Platte River	23,294	
		51,811
Platte River at Columbus, Nebraska		56,867
Platte River, North and South, in Colorado[1]	22,230	
Platte River in Nebraska	10,850	
Platte River in Wyoming	24,240	
		57,320

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

	Square miles.
Portneuf River at McCammon, Idaho	500
Potomac River, North Branch, above Bloomington, Maryland	293
Potomac River, North Branch, at Piedmont, West Virginia (including Savage Creek, 111)	409
Potomac River, North Branch, at Cumberland, Maryland (including New Creek, at mouth, at Keyser, West Virginia, 56)	891
Potomac River, North Branch, at junction with South Branch (including Patterson Creek at Burlington, below Mill Creek, 155, and at mouth, 279)	1,365
Potomac River, South Branch, at junction with North Fork (including at Franklin, 188)	318
Potomac River, South Branch, including North Fork (including North Fork below Seneca Creek, 240, and at mouth, 322)	640
Potomac River, South Branch, at Moorefield, West Virginia (including Mill Creek at mouth, 101)	897
Potomac River, South Branch, below Moorefield (including South Fork at Fort Seybert, West Virginia, 155, and at mouth at Moorefield, 301)	1,198
Potomac River, South Branch, at Romney, West Virginia	1,407
Potomac River, South Branch, at United States Geological Survey station at railway bridge, between Romney and Springfield, West Virginia	1,443
Potomac River, South Branch, at mouth	1,487
Potomac River at junction of North and South branches	2,852
Potomac River above Great Cacapon River (including Little Cacapon River, 117)	3,388
Potomac River below Great Cacapon River (including Great Cacapon above North River, 404, and at mouth, 671)	4,059
Potomac River at Hancock, West Virginia	4,099
Potomac River at Williamsport, Maryland (including Warm Spring Creek at mouth, 16; Conoloway Creek, 125; Sleepy Creek, 146; Licking Creek, 195; Back Creek, 288, and Conocheague Creek, 579)	5,556
Potomac River at Harpers Ferry, West Virginia (including Opequon Creek, 335; Antietam Creek, 305)	6,354
Potomac River below Harpers Ferry, West Virginia (including Shenandoah River, 3,009)	9,363
Potomac River at Weverton, Maryland	9,397
Potomac River at Point of Rocks, Maryland	9,654
Potomac River at Edwards Ferry, below Goose Creek (including Monocacy River at mouth, 941, and Goose Creek, 384)	11,100
Potomac River at Great Falls, Maryland (including Seneca Creek, 132)	11,427
Potomac River at Chain Bridge, District of Columbia	11,545
Prosser Creek at Boca, California	55
Provo River at Provo, Utah	640
Purgatoire River at Trinidad, Colorado	742
Purgatoire River at Las Animas, Colorado	3,040
Red Rock Creek at Redrock, Montana	1,330
Republican River, North Fork, at Haigler, Nebraska	1,390
Republican River at Superior, Nebraska	22,347
Republican River at Junction City, Kansas	25,837
Republican River in Colorado	7,926
Republican River in Nebraska	10,415
Republican River in Kansas	7,496
	25,837
Rio Grande at Del Norte, Colorado	1,400
Rio Grande at Embudo, New Mexico	7,000
Rio Grande at Rio Grande, New Mexico	11,250
Rio Grande at El Paso, Texas	30,000
Rio Grande in Colorado[1]	7,527
Rio Grande in New Mexico (including Pecos River)	72,380
Rio Grande in Texas	80,550
	160,457
Roanoke River at Roanoke, Virginia	388
Roanoke River at Clarksville, Virginia	7,344
Roanoke River at Neal, North Carolina	8,717
Rock Creek at Battle Mountain, Nevada	725
Rock Creek, Little, at Palmdale, California	78
Sacramento River at Jellys Ferry, California	9,134
Sacramento River above Redbluff, California	9,356

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

	Square miles.	
Sacramento and San Joaquin rivers in California	63,020	
Sacramento River	655	
		63,675
Salt River below Tonto Creek, Arizona		5,756
Salt River in canyon 20 miles above Verde		5,880
Salt River at Arizona Dam, Arizona		12,260
Saline River at Beverly, Kansas		2,730
Saline River at mouth, Kansas		3,311
Saluda River at Waterloo, South Carolina		1,056
San Emidio Creek, California		54
San Gabriel River in canyon above Azusa, California		220
San Joaquin River above Hamptonville, California		1,637
San Juan River at Arboles, Colorado		1,394
San Miguel River at Seymour, Colorado		327
San Pedro River at Dudleyville, Arizona		2,870
Santa Ana River at Warm Springs, Colorado		184
Savannah River below Rocky River, at Calhoun Falls, South Carolina, above Beaverdam Creek		2,712
Savannah River above Augusta, Georgia		7,294
Sevier River at Leamington, Utah		5,595
Shenandoah River (North Fork) at Brocks Gap, Virginia		215
Shenandoah River (North Fork) at Mount Jackson, Virginia		511
Shenandoah River (North Fork) at Riverton, Virginia		1,037
Shenandoah River (South Fork) at Port Republic, Virginia (including Middle River to junction with North River, 363; North River to junction with Middle River, 418; to junction with South River, 804; South River to junction with North River, 246)		1,050
Shenandoah River (South Fork) at Milnes, Virginia		1,288
Shenandoah River (South Fork) at Overall, Virginia		1,491
Shenandoah River (South Fork) at mouth at Riverton, Virginia		1,587
Shenandoah River at Riverton, Virginia (including North Fork, 1,037, and South Fork, 1,587)		2,624
Shenandoah River at Millville, West Virginia		2,995
Shenandoah River at mouth at Harpers Ferry, West Virginia		3,009
Shoshone River at Corbett, Wyoming		1,718
Shoshone River, South Fork, at Marquette, Wyoming		500
Smoky Hill River at Ellsworth, Kansas (including in Colorado 1,533, in Kansas 6,447)		7,980
Smoky Hill River below Ellsworth, exclusive of Saline and Solomon rivers.		2,255
Smoky Hill River at mouth at Junction City, Kansas		20,428
Snake River, North Fork, at Ferry, Idaho		931
Snake River at Idaho Falls, Idaho		10,100
Snake River at Montgomery Ferry, Idaho		22,600
Snake River in Idaho[1]	73,500	
Snake River in Nevada	5,280	
Snake River in Oregon	17,950	
Snake River in Washington	6,682	
Snake River in Wyoming	5,268	
		108,680
Solomon River at Beloit, Kansas		5,539
Solomon River at mouth, Kansas		6,882
South River at Port Republic, Virginia		1,050
South Platte River at Deansbury, Colorado		2,600
South Platte River at Denver, Colorado (including Bear Creek at Morrison, 170)		3,840
South Platte River at Greeley, Colorado, above mouth of Cache la Poudre River		7,110
South Platte River below Greeley, Colorado		9,575
South Platte River at Orchard, Colorado		12,260
South Platte River at mouth at North Platte River, Nebraska		23,294
Spanish Fork near Spanish Fork, Utah		670
Spokane River at Spokane, Washington		4,005
St. Vrain Creek near Lyons, Colorado		209
Stanislaus River at Oakdale, California		1,051
Staunton River at Clarksville, Virginia		3,546
Sun River at Augusta, Montana		1,175

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

	Square miles.
Sweetwater River (Wyoming) at mouth	2,929
Sweetwater River at Sweetwater Dam, California	186
Tar River at Tarboro, North Carolina	2,290
Tejon House Creek at Tejon Ranch House, Kern County, California	17
Tennessee River, Little, at Judson, North Carolina	682
Teton River at Wilford, Idaho	967
Thompson Creek near Loveland, Colorado	305
Tongue River at Miles, Montana	3,875
Truckee (Little) River at Boca, California	186
Truckee River at Boca, California	887
Truckee River at Tahoe, California	550
Truckee River near Essex, Nevada	991
Truckee River near Laughtons, Nevada	1,054
Truckee River near Vista, Nevada	1,519
Tuckaseegee River 3 miles above Bryson, North Carolina	609
Tule River above Portersville, California	437
Tuolumne River above Roberts Ferry, California, at foothills	1,501
Tuolumne River at Modesto	1,635
Twin Lake Creek below Twinlakes, Colorado	102
Umatilla River at Gibbon, Oregon	353
Umatilla River at Pendleton, Oregon	640
Uncompahgre River at Fort Crawford, Colorado	497
Verde River 1 mile above Salt River	6,000
Verdigris River at Independence, Kansas	3,067
Weber River at Uinta, Utah	1,600
Weiser River at Weiser, Idaho	1,670
West Gallatin River above Salesville, Montana	860
White River at White River City, Colorado	1,773
Wood River at Hailey, Idaho	906
Wood River, Little, at Taponis, Idaho	1,270
Yadkin River at Holtsburg, North Carolina	3,399
Yadkin River at Norwood, North Carolina	4,614
Yakima River at Union Gap, Washington (of this, Tiaton, 330)	3,300
Yakima River at Kiona, Washington	5,230
Yellowstone River at Horr, Montana	2,700
Yellowstone River in Montana[1] 36,312	
Yellowstone River in North Dakota 250	
Yellowstone River in Wyoming 33,121	
	69,683

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894, octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895, octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896, octavo, 864 pp.

Contains papers by G. K. Gilbert on the underground water of the Arkansas Valley in eastern Colorado; by Frank Leverett on the water resources of Illinois, and by N. H. Darton on a reconnaissance of the artesian areas of a portion of the Dakotas.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896, octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896, octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897, octavo, — pp. (In preparation.)

Contains a progress report of stream measurements for the year 1896, by Arthur P. Davis, and four other papers relating to hydrography. The first of these is by Frank Leverett, and relates to the water resources of Ohio and Indiana, especially as obtained by wells; the next is by N. H. Darton, on the artesian waters of South Dakota, being supplementary to his paper in the Seventeenth Annual; following this is a fully illustrated paper, by James D. Schuyler, on water storage, mainly for irrigation and the construction of dams; the last paper, by Robert T. Hill, describes the artesian conditions of a portion of Texas in the vicinity of San Antonio.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897
7. Seepage waters of northern Utah, by Samuel Fortier.
8. Windmills for irrigation, by E. C. Murphy.
9. Irrigation near Greeley, Colorado, by David Boyd.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker.
11. River heights for 1896, by Arthur P. Davis.

In preparation:

12. Water resources of southeastern Nebraska, by Nelson Horatio Darton.
13. Water resources of the Devils Lake region, North Dakota, by Earle J. Babcock.
14. Irrigation in the upper portion of San Joaquin Valley, by C. E. Grunsky.

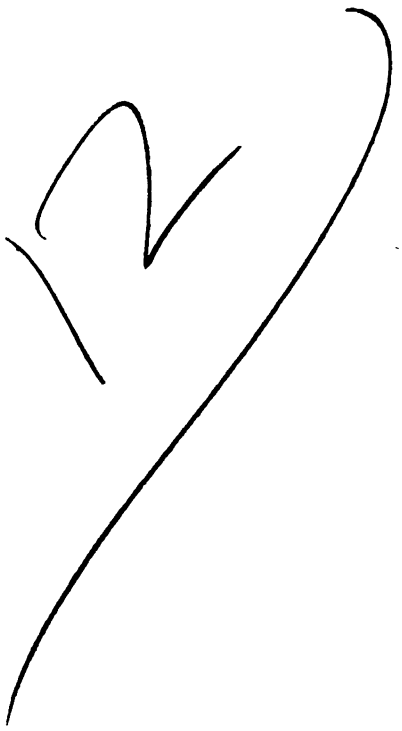
In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved, June 11, 1896; Stat. L., vol. 29, p. 453.)

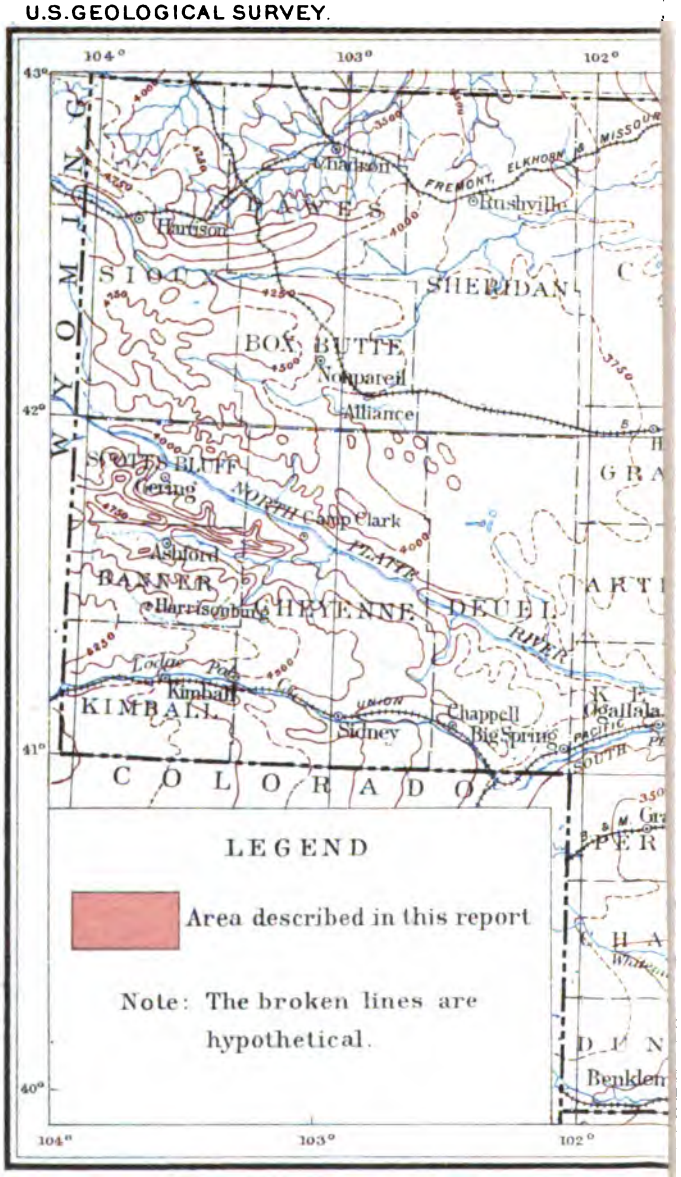
The maximum number of copies available for the use of the Geological Survey is 1,000. This quantity falls far short of the demand, so that it is impossible to supply all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or donation of data. Requests specifying a certain paper and stating a reason for asking for it are attended to whenever practicable, but it is impossible to comply with general demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.



U.S.GEOLOGICAL SURVEY.



CONTOUR MAP OF NEBR

55TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 453.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 12

UNDERGROUND WATERS OF A PORTION OF SOUTHEASTERN NEBRASKA.—DARTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

UNDERGROUND WATERS

OF

A PORTION OF SOUTHEASTERN NEBRASKA

BY

NELSON HORATIO DARTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

CONTENTS.

	Page.
Letter of transmittal	9
Introduction	11
Topography	12
Geology	14
General structure	14
Formations	15
Carboniferous formations	15
Dakota sandstone	16
Benton and Niobrara formations	19
Pierre shales	20
Neocene formations	20
Earlier Pleistocene deposits	21
Loess	22
Alluvium	23
Dune sands	23
The water horizons	24
Lancaster County	27
Seward County	30
Northern Saline County	32
York County	32
Fillmore County	34
Hamilton County	35
Clay County	36
Hall County	36
Adams County	37
Buffalo County	39
Gage wells at Kearney	40
Kearney County	42
Phelps County	42
Dawson County	43
Northern Gosper County	44
Prospects for deeper-seated waters	45
Irrigation by underground waters	48
Lancaster County	48
Seward County	49
Fillmore County	50
York County	50
Hamilton County	50
Buffalo County	50
Dawson County	51
Index	55

ILLUSTRATIONS.

		Page.
PLATE I.	Contour map of Nebraska	1
II.	Platte River near Ashland, Nebraska, showing stream deposits	10
III.	Geologic map of a portion of southeastern Nebraska	12
IV.	Section from the Rocky Mountains across Wyoming and Nebraska	14
V.	Juratrias red sandstones, sands, etc., at entrance to Garden of the Gods, near Manitou, Colorado	16
VI.	Dakota sandstone lying on Carboniferous limestone, west bank of Missouri River, at mouth of Platte River	18
VII.	Dakota sandstone on west bank of Missouri River, at mouth of Platte River	18
VIII.	Exposure of Dakota sandstone on Antelope Creek in southeastern portion of Lincoln, Nebraska	20
IX.	Dakota sandstone overlain by glacial drift, near Bennett, Nebraska	22
X.	Dakota sand in quarry just southeast of Bennett, Nebraska	22
XI.	Niobrara limestone on Coon Creek, in southern portion of Milford, Nebraska	24
XII.	Typical fossils of Niobrara limestone	24
XIII.	Typical stony drift surface, northern Lancaster County, Nebraska	26
XIV.	Glacial drift on Dakota clay in pits southwest of insane asylum near Lincoln, Nebraska	28
XV.	Loess on glacial drift and Dakota clay in clay pits southeast of insane asylum near Lincoln, Nebraska	28
XVI.	Recent valley deposits along Salt Creek, in eastern portion of Lancaster County, Nebraska	30
XVII.	Map of a portion of southeastern Nebraska, showing the depths to water-bearing formations	32
XVIII.	Sections illustrating some special conditions affecting underground waters in south-central Nebraska	34
XIX.	Spring from Dakota sandstone along Missouri River near mouth of Platte River, Sarpy County, Nebraska	36
XX.	Map showing contour and relations of surface of Dakota sandstone in the vicinity of Lincoln, Nebraska	38
XXI.	Cross sections showing relations of Dakota sandstone in the vicinity of Lincoln, Nebraska	40
FIG. 1.	Typical sand dune with "blow-out"	13
2.	Section of Carboniferous beds in quarries near Roca, Nebraska	15
3.	Cross section at Bennett, Nebraska	18
4.	Glacial formations in railroad cut near Prairie Home, Nebraska	22
5.	Ideal section showing the usual relations of underground waters in the central plains region of Nebraska	25
6.	Ideal section from the Platte Valley to and down the valley of West Blue River, to show the probable cause of the flow	26

		Page.
FIG. 7.	Record of deep boring of salt well near Lincoln, Nebraska	29
8.	Record of deep boring at Seward, Nebraska	31
9.	Record of deep well at Fairmont, Nebraska	35
10.	Record of deep boring at Hastings, Nebraska	38
11.	Map showing location of gage wells at Kearney, Nebraska	39
12.	Profile of line of wells along Central avenue, Kearney, Nebraska	40
13.	Diagram of apparatus for illustrating the declivity of head of liquids flowing from a reservoir	46
14.	Record of deep boring at Dannebrog, Howard County, Nebraska	47

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, June 14, 1897.

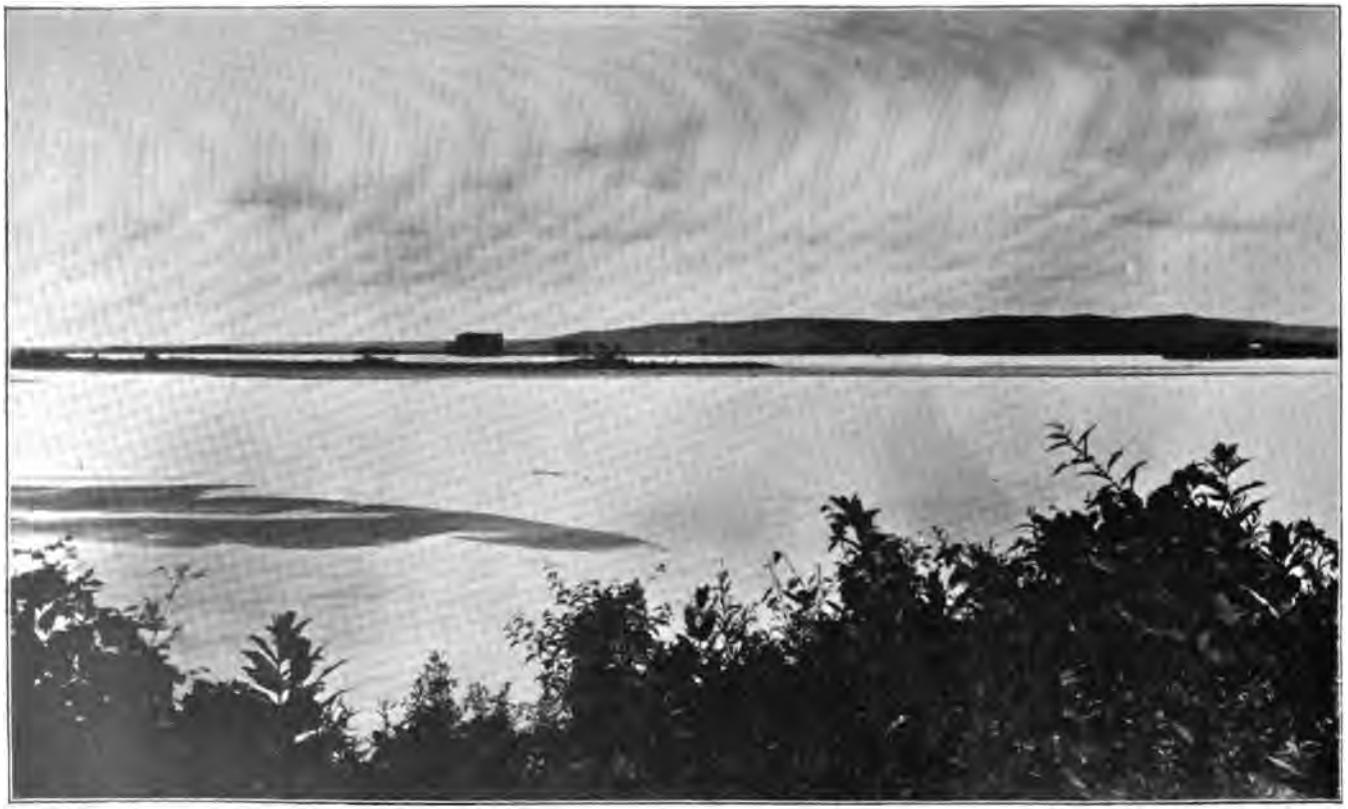
SIR: I have the honor to transmit herewith a manuscript prepared by Mr. N. H. Darton, assistant geologist of this Survey, relating to the underground or well waters of a portion of the State of Nebraska. The facts given are the results of field work in this State during the season of 1896. Beginning in the vicinity of Lincoln, Nebraska, Mr. Darton not only made a detailed examination of the surface geology, but carried on a careful search for all wells, both shallow and deep. As far as possible, information was obtained concerning the depth of the wells, the character of the strata penetrated, and the volume and quality of the water supply. This work was conducted westward to the vicinity of Lexington. In this work Mr. Darton was assisted by Mr. Joseph E. Macfarland, a young man whose untimely death at the end of the field season deprived the Survey of the services of one of its most promising and energetic junior geologists.

To a discussion of the geologic formations and their water contents Mr. Darton has appended a statement as to the possibility of obtaining artesian water, adding such facts as were procurable concerning the utilization of the available water supply in irrigation. In this particular area agriculture is not regarded as dependent, to any considerable extent, upon the artificial application of water, but the examples cited show that in many localities irrigation on a small scale can be employed with profit. It is proposed during the coming field season to extend this investigation westward into the areas where the necessity for irrigation has long been recognized and where water supplies have a still greater value. The field work is confined largely to the areas of which topographic maps have been prepared, as without such maps studies of underground waters are necessarily vague and inconclusive.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



PLATTE RIVER NEAR ASHLAND, NEBRASKA, SHOWING STREAM DEPOSITS.

UNDERGROUND WATERS OF A PORTION OF SOUTHEASTERN NEBRASKA.

By NELSON HORATIO DARTON.

INTRODUCTION.

This report relates to underground waters in Lancaster, Seward, northern Saline, York, Fillmore, Hamilton, Clay, Hall, Adams, Buffalo, Kearney, Phelps, northern Gosper, and eastern and central Dawson counties, an area of about 6,700 square miles.[1] It is the result of observations made with the assistance of Messrs. J. E. Macfarland and C. A. Fisher in the summer and autumn of 1896. It deals mainly with waters occurring at moderate depths, but also briefly reviews the probabilities of obtaining water supplies from deeper-seated sources.

The region is one in which the average annual rainfall is not sufficient to insure full crops every season, even in the eastern part of the area, where the rainfall is considerably greater than in the western counties. Fortunately, very nearly all of this region is underlain by water-bearing deposits, which in most districts yield good supplies of water to pump wells. The depth to this water varies from less than 10 feet in the valley of Platte River to somewhat over 300 feet in the higher plateau areas of Dawson and Gosper counties and in a few instances in the high drift hills of Lancaster County. The supply is also variable in amount, but in most cases the average windmill does not lower its level. The waters have been used to some extent for irrigation, and the results have been entirely satisfactory, so far as the crops are concerned. In most cases a single windmill has not proved adequate to supply water for the irrigation of over 15 acres, under the most favorable conditions, and in the deeper wells, or where the water is more scanty in supply, the limitations are greater. This acreage is, however, sufficient for the cultivation of a profitable diversified crop, large enough at least to carry a family over a dry season. It is not the purpose of this report to discuss the efficacy of

[1] The greater part of this area is covered by topographic atlas sheets of the Survey, as follows: *Lincoln*, York, *Grand Island*, *Wood River*, *Kearney*, and *Lexington*, of which those in italics are now ready for sale at 5 cents each.

windmills, which it is believed can be greatly increased, nor the prospects for irrigation in the district. The location and extent of the underground water will be set forth mainly by maps, which will also give information in regard to the conditions of its occurrence.

TOPOGRAPHY OF THE DISTRICT.

The region to which this report relates lies on the eastern slope of the Great Plains which extend from the Rocky Mountains toward the Mississippi River. It comprises several types of land forms. The greater part of the area is a smooth plain, sloping gently eastward from an altitude of 2,700 feet near the one hundredth meridian to about 1,400 feet in the vicinity of the ninety-seventh meridian—a slope of about 7 feet to the mile. Westward this plain is widely trenched by the broad valley of Platte River, which lies from 80 to 160 feet below the plains surface. There are also other valleys of moderate width, of which the largest are those of the Big and Little Blue rivers and their branches, South Fork of Loup River, Wood River, and Plum Creek. To the east, in eastern Seward and Lancaster counties, the smooth plains give place to a region of high drift hills, deeply intersected by wide valleys. Another characteristic feature of the region is the sand-dune areas, mainly along the south side of the valleys of Platte and Loup rivers.

The valley of Platte River is 20 miles wide in Hall County, but it narrows considerably toward the west. East of Kearney, where it is also occupied by Wood River, a branch of Platte River, the valley is 12 miles wide. At Kearney the width rapidly diminishes to 8 miles, and this width continues some miles westward. In Dawson County the valley widens to 15 miles. The floor of the valley of Platte River is a very smooth plain, sloping gently toward the east. The river flows in channels but slightly depressed below the valley floor, and in dry seasons the water meanders through these channels in small ramifying rivulets, with intervening sand banks of various sizes. The character of these sand banks is shown in Pl. II.

There are some islands which are submerged only in times of high water; the principal one, known as Grand Island, has a length of 42 miles and owes its isolation to a narrow channel which passes around its northwestern side. The river usually does not occupy the center of the valley, but has a general disposition to hug its south side. In Hamilton County the principal channel is at the bottom of the slope which rises to the higher plain. East of longitude 99° 30′ the valley of Platte River is depressed from 80 to 100 feet below the surface of the adjoining plains, but the depth gradually increases in Dawson County to over 150 feet. Wood River has a level-floored valley, which merges into that of the Platte just north of Kearney. The South Fork of Loup River flows in a valley which averages about a mile in width in the northern part of Buffalo County.

SC

TOPO

In Seward, Saline, York, Fillmore, Hamilton, Clay, Adams, Kearney, and eastern Phelps counties the plains present very broad areas of smooth surface, and often extend uninterruptedly for many miles. They are, however, more or less deeply trenched by the branches of Big and Little Blue rivers, and toward the west, where the land rises higher above the adjoining valleys, the plains are very much cut up by small branch brooklets, so that much of the higher region of Buffalo, Dawson, and Gosper counties consists of narrow ridges, usually with steep slopes, separated by numerous narrow valleys. In Gosper County these valleys assume a canyon type, particularly along the steep slope on the south side of the Platte Valley and in the slopes extending southward toward the Republican Valley.

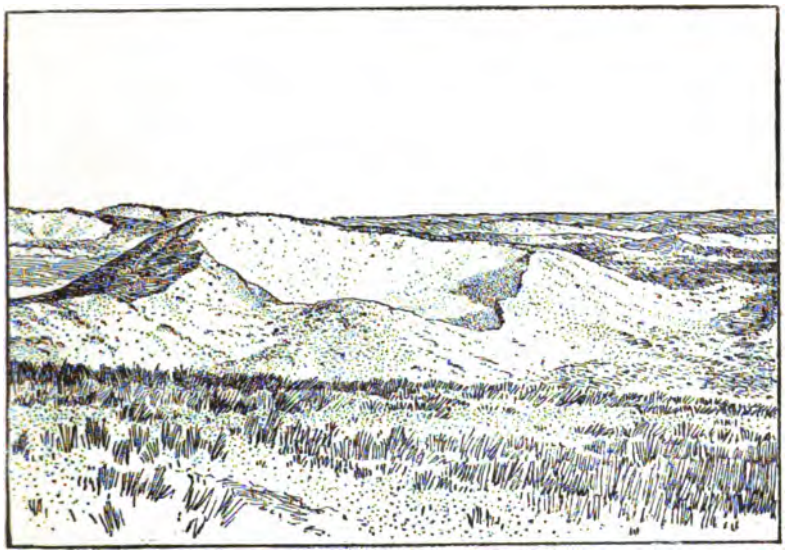


FIG. 1.—Typical sand dune with "blow-out" in its top.

In the drift-hill region of Lancaster and adjoining counties another type of topography is presented. There are high, rolling hills in long, irregular ridges separated by wide, level-floored valleys, of which the Salt Creek Valley with its branches is the most extensive. Lincoln is built at a confluence of a number of branches of Salt Creek and along the adjoining slopes of the drift hills. The drift surface rises to an altitude of about 1,550 feet in the eastern portion of Seward County, but the altitude to which the higher summits rise eastward gradually diminishes to from 1,300 to 1,400 feet in the eastern portion of Lancaster County. The bottom of the valley in which Lincoln is situated has an altitude of about 1,150 feet.

Areas of sand dunes are very frequent in the Platte and Loup valleys in Hall, Buffalo, Adams, Kearney, and Phelps counties. Some smaller areas also occur in Dawson County and on the high plains

and slopes about the head waters of Little Blue River in western Adams and eastern Kearney counties. The areas are characterized by their irregular, hummocky contour and loose sand surfaces. Some of the higher mounds rise 100 feet above the adjacent lowlands and are conspicuous features in the landscape. There are many basins among the hills and meandering valleys which have no outlets. The largest bodies of the sand extend for 50 miles along the south side of the Platte Valley south of Kearney, lying mainly against the slope which rises to the higher plains. There are also extensive deposits south of the South Fork of Loup River in northern Buffalo and Hall counties. The width of the wider portions of these sand-dune belts is about 3 miles. A "blow-out," a characteristic feature in some of the sand-dune areas, is shown in fig. 1 (p. 13.)

GEOLOGY.

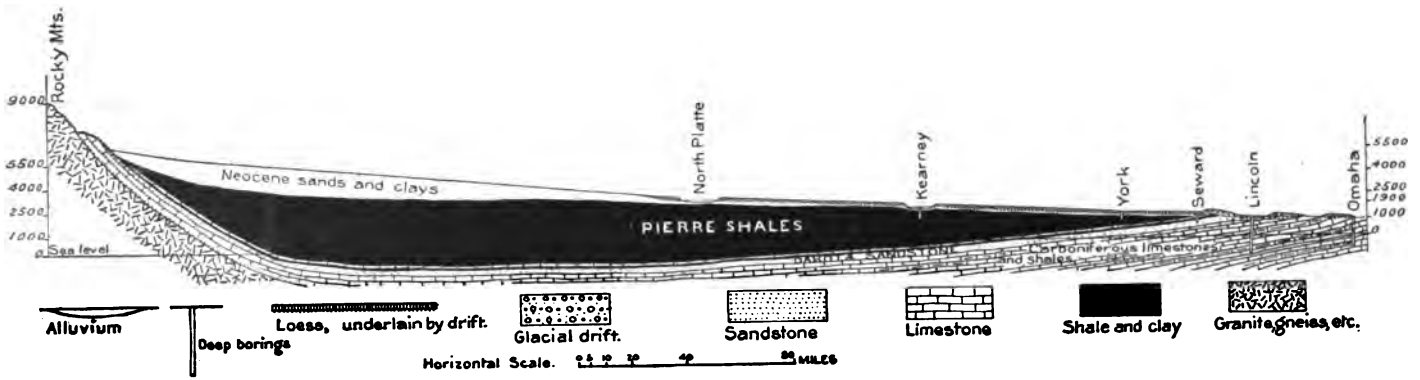
GENERAL STRUCTURE.

Southeastern Nebraska is underlain by Carboniferous and Cretaceous formations bearing a superficial mantle of Pleistocene deposits. The older formations have a gentle slope toward the west, and the overlying deposits are in general conformable to the eastward slope of the land. In Pl. IV is given a cross section from the Rocky Mountains to the Missouri River at Omaha, showing the general structural relations.

East of the longitude of Lincoln the limestone and associated rocks of the Carboniferous formation reach the surface, and they are frequently exposed in the valleys in the southeastern corner of the State. Toward the west their gentle dip and the rapid rise of the land carry them far beneath the surface, so that in the vicinity of the ninety-ninth meridian they appear to lie at a depth greater than 3,000 feet. Farther westward they may or may not increase in depth, but they rise in approaching the Rocky Mountains and outcrop high on the slopes of these mountains in Colorado and Wyoming.

The series of Cretaceous formations which lie on the Carboniferous beds comprises the Dakota sandstone, the Benton shales, the Niobrara limestone, and the Pierre shales. The lowest member, the Dakota sandstone, reaches the surface, to the eastward, in a zone which passes near Lincoln.

In the slopes of the Rocky Mountains the Dakota sandstone is separated from the Carboniferous beds by the Juratrias red sandstones, sands, and clay, which probably extend for some distance eastward, no doubt under the western portion of Nebraska, but they do not reach the surface in the eastern portion of the State. A characteristic exposure of these beds on the eastern slope of the Rocky Mountains is given in Pl. V. Near the ninety-seventh meridian the Dakota sandstone passes under the thin series of Benton shales and Niobrara limestones, and these in turn soon disappear beneath a mass



SECTION FROM THE ROCKY MOUNTAINS ACROSS WYOMING AND NEBRASKA.

of Pierre shales, which attain a thickness of over 3,500 feet under the central and western portion of the State. The Carboniferous and Cretaceous formations in the eastern part of the State are heavily overlain by Pleistocene deposits, comprising a large mass of glacial drift and a thick mantling of loess. West of longitude 98° 30′ there intervenes between the Pleistocene deposits and the Cretaceous formations a series of Neocene deposits, which gradually thicken toward the west, and finally, rising above the slope on which the loess lies, become the dominant surface formations in the western portion of the State. The glacial drift is a thick mass in Lancaster County. It thins rapidly toward Missouri River and westward, its attenuated margin passing under a thick sheet of loess in both directions. Toward the west the larger mass of glacial drift presents an obscure morainal front along the eastern side of Seward County, from which a continuous thick mantle of loess extends far westward. Under this loess mantle there is a thin sheet of drift materials extending out from the front of glacial drift. West of latitude 98° 30′ a thin wedge of calcareous

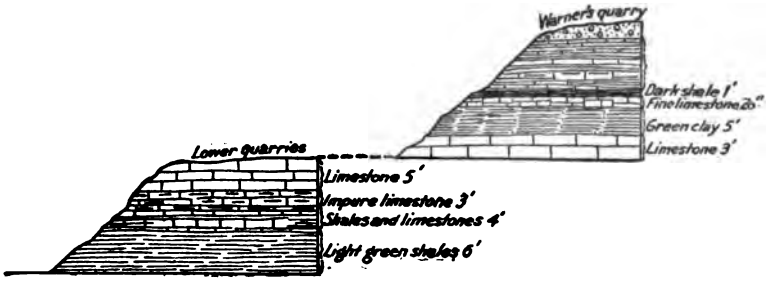


FIG. 2.—Section of Carboniferous beds in quarries near Roca, Nebraska.

and siliceous sediments, of Neocene age, comes in between the loess and drift and the Pierre shale surface, gradually thickening toward the west. The loess mantle is widely trenched by the valley of Platte River and more or less deeply excavated by the other valleys, which are often cut through to the underlying Pleistocene and Neocene formations.

The loess has a thickness of from 60 to 90 feet in greater part. Flooring the large depressions that traverse the region are deposits of alluvial formations, which are of great width along Platte River. In some portions of the area there are accumulations of dune sands of greater or less extent, and these, aside from sand banks in the rivers, are the most recent formations of the region.

THE FORMATIONS.

Carboniferous.—Carboniferous limestones reach the surface in southern, central, and eastern Lancaster County. They consist of a variety of limestone beds with intercalated shales and clays. The principal exposures are in the vicinity of Roca, near Hickman, and

about Bennett. At these localities the rocks have been quarried, notably about Roca, where they have furnished large amounts of fine building stone. A columnar section of the rocks at Roca is given in fig. 2 (p. 15), which comprises all the members exposed in the quarry just north of Roca station and in the Warner quarries and depressions a mile north of the village.

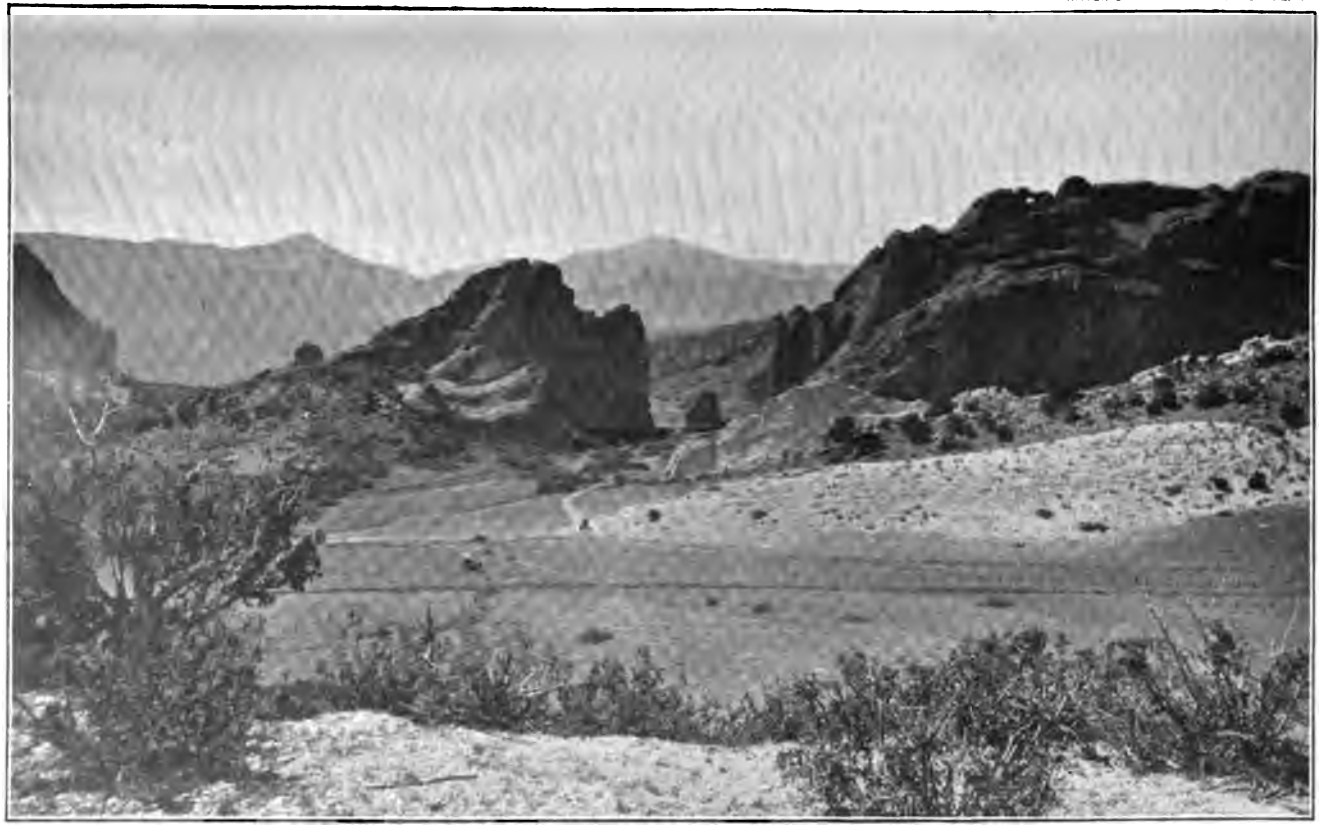
From the beds in Warner's quarry Mr. Macfarland collected the following fossils:

Euomphalus rugosus.	P. cora.
Setopora biserialis?	P. nebrascensis.
Marginifera splendens.	Chonetes flemingi.
Spirifer cameratus.	C. granulifera.
Meekella striatocostata.	Fusilina cylindrica.
Seminula subtilita.	Ambocœlia planoconvexa.
Derbya crassa.	Orthis (Rhipidomella) carbonaria.
Rhombopora lepidodendroides.	Pugnax uta.
Productus semireticularis.	Orbiculoida sp.

At Bennett some different members of the formation are exposed, and so far it has not been possible to ascertain the relative positions of the rocks of the two areas. Probably in the region between Roca and Bennett and toward the south the Carboniferous beds are not far beneath the surface in the deeper hollows, but they are covered by the general heavy drift mantling. In the deep borings at Lincoln the Carboniferous beds were penetrated to a depth of over 1,000 feet. They appear to begin at a depth of about 269 feet. The section given in fig. 7, page 29, illustrates the general succession of deposits.[1]

Dakota sandstone.—In eastern Nebraska the Carboniferous formations are overlain directly by the Dakota sandstone, without trace of the Juratrias deposits intervening. At a point a mile and a half due north of Roca station the contact may be seen; at Bennett the two formations are in immediate proximity; and in the wells at Lincoln the contact lies about 269 feet beneath the surface. A finely exposed contact is shown in Pl. VI. The contact line between the Dakota sandstone and the Carboniferous beds in eastern Nebraska presents many steep slopes, indicating an irregular shore line against which Dakota sediments were deposited. The materials of the Dakota formation are mainly gray and brown sandstone, but there are also intercalated clays of various colors. Portions of the sandstone are highly ferruginous, so much so as to be frequently mistaken for iron ore. The sandy character of the formation is, however, prominent throughout. Where the amount of iron is large the rock is very apt to have a highly concretionary structure. The coarser sandy members are usually cross bedded. A characteristic outcrop is shown in Pl. VII. The texture of the sandstone varies irregularly from

[1] A more detailed description of the beds is given by Mr. B. P. Russell in the Sixth Biennial Report of the Commissioner of Public Lands and Buildings to the Governor of Nebraska, 1888, pp. 57-84. Lincoln, 1888.



JURATRIAS RED SANDSTONES, SANDS, ETC., AT ENTRANCE TO GARDEN OF THE GODS, NEAR MANITOU, COLORADO.

rock which is quite firm to sand which is hardly consolidated. In most cases the material is a soft sandstone which can be easily excavated with the pick. Some of the firmer beds contain fossil leaves in considerable abundance.

In the region covered by this report the exposures of Dakota sandstone are confined to Lancaster County and the vicinity of Pleasantdale in eastern Seward County. They occur at intervals along the sides of depressions of branches of Salt Creek, and at Bennett at the head of the Little Nemaha River. They are mainly very small and quite widely scattered, and are due chiefly to the excavation of depressions which have been cut through the glacial drift. Their location is shown in Pl. III (p. 12). In some cases belts of exposures mark the presence of a ridge of Dakota sandstone under the drift. The most extensive outcrops occur at intervals along and near the Burlington and Missouri River Railroad from Lincoln nearly to Roca, on the western slope of the ridge on the east side of Southeast Salt Creek. There are quite extensive exposures about the penitentiary and in the vicinity of the Chicago, Rock Island and Pacific Railroad crossing. Just east of Saltillo gray sandstones appear halfway up the slope, and they are again exposed on the point of the next ridge 2 miles farther south, lying against the Carboniferous limestone. The brown sandstones appear on Antelope Creek in the southeastern corner of Lincoln, as shown in Pl. VIII, at the "cave" in the southern margin of the city, and at the crossing of the Chicago, Rock Island and Pacific Railroad and Burlington and Missouri River Railroad, Nebraska City branch. Between Emerald and Pleasantdale the Dakota sandstone rises as a moderately high ridge under the drift and is exposed in a number of railroad and stream cuts. The beds are extensively cross bedded, and in some of the exposures consist of a highly ferruginous sandstone with complex concretionary structure. There are several exposures on both slopes of Haines Branch Valley and along the hollow beginning 2 miles southwest of Rokeby. They are of the usual brown sandstone. At the brick and tile works a mile southwest of the insane asylum the formation is represented by clays mainly of mottled pink, brown, and gray colors, with streaks of sand and sandstone and a bed of dark-gray clay containing a large amount of organic material. The clays have been mined extensively at this place for brick and tile, for which they appear well suited. They are overlain by a small amount of drift and a considerable mass of fossiliferous loess. Some of the features of this exposure are shown in Pls. XIV and XV.

There is another excavation in a similar mass of clay in the southern edge of West Lincoln, just east of the lake. The exposures of Dakota sandstone north of Lincoln are along Little Salt Creek and some of its branches south and southwest of Davey, along Rock Creek north of Waverly, and in depressions along the head branches of Rock

Creek northeast of Davey. In all of these exposures there is seen brown sandstone, excepting in the railroad cut northeast of Davey, where a mottled clay is exposed. The only exposures discovered east of Lincoln are in a small branch of Stevens Creek 6½ miles east of the Lincoln post-office, at an old quarry in the north side of Stevens Creek a mile and half above its mouth, and in the hollow just north of the railroad a mile west of Prairie Home. The exposure of the Dakota sandstone just south of Bennett, at the head of the Little Nemaha River, is very interesting. The formation consists of quite regular beds, from 1 foot to 2 feet in thickness, of beautifully cross-bedded sands hardly sufficiently cemented together to be classed as sandstone. The exposure is across a depression from limestone, as shown in fig. 3. The relations indicate that probably there was here a steep shore of the limestone during the deposition of the Dakota sandstone, although possibly the two formations are separated by a fault. In Pls. IX and X there are reproduced photographs of portions of the exposure, showing the cross bedding very clearly. In Pl. IX the overlying glacial drift is also shown.

FIG. 3.—Cross section at Bennett, Nebraska; looking north.

The Dakota sandstone has been reported in many of the wells in Lancaster County, and in fact it is one of the principal sources of water supply in the deeper wells.

In the boring made by the State near Lincoln in 1886 the lower portion of the Dakota formation was penetrated. According to Mr. B. P. Russell,[1] the materials covering the Carboniferous limestone were as follows:

Feet.	
0 – 4	.....Sandy loam.
4 – 20	.....Angular greenish sand.
20 – 24½	.....Coarser whitish sand.
24½ – 48½	.....Coarse gravel.
48½ – 52	.....Sand, whitish, even grained, in part rounded.
52 – 57	.....Coarse gravel.
57 – 74	.....Fine yellow sand.
74 –100	.....Lighter sand.
100 –112½	.....Coarser, dark-yellow sand; gravel and iron pebbles.
112½ –133¾	.....White sand and gravel, with brine at 119 feet.
133¾ –135	.....Yellowish-white sand.
135 –147½	.....Yellow sand; small pebbles.

[1] Sixth Biennial Report of the Commissioner of Public Lands and Buildings, December 1, 1888, pp. 65-68. A slightly different record is given in the Fifth Report, 1886, p. 19.

DAKOTA SANDSTONE LYING ON CARBONIFEROUS LIMESTONE, WEST BANK OF MISSOURI RIVER, AT MOUTH OF PLATTE RIVER.

(The arrows indicate the plane of contact.)

DAKOTA SANDSTONE ON WEST BANK OF MISSOURI RIVER, AT MOUTH OF PLATTE RIVER.

Shows cross bedding and beds of coarse materials.

Feet.		
147½ –164½	Coarse yellow sand and gravel.	
164½ –179½	Yellow sand.	
179½ –195	White sand; gravel.	
195 –202	Very coarse gravel.	Containing brine 35°; strong flow.
202 –205	Coarse gravel and conglomerates.	
205 –206½	Coarse conglomerate with chalky, flinty pebbles.	
206½ –208½	Soft gray sandstone.	
208½ –209½	Reddish clay.	
209½ –214½	Light-drab clay.	
214½ –244½	Fine-grained, gray, very soft sandstone.	
244½ –247½	Greenish-drab clay.	
247½ –267 1/3	Fine-grained, reddish, very soft sandstone.	
267 1/3–269 1/3	Arenaceous gray clay lying on chert, shale, and limestone.	

It is thought that the top of the Dakota formation was entered at a depth of 48½ feet, but the evidence is by no means conclusive.

From the data of wells and outcrops in the Lincoln region it has been possible to prepare a map (Pl. XX) with contour lines showing the altitude of the surface of the Dakota sandstone under a portion of Lancaster County and adjoining area. These lines are intended to indicate the contour of the sandstone surface on which the drift deposits lie. An endeavor has also been made to differentiate the valleys cut into the sandstone in areas from which the drift has been removed, as, for instance, along the center of the Salt Creek and Southeast Salt Creek valleys. A further explanation of the relations is shown by cross sections in Pl. XXI. The irregularities of contour are probably mainly due to preglacial erosion, but there is some evidence that the elevated area about Pleasantdale is due in part to an upward arching of the beds.

In Pl. XVII the depth of the Dakota sandstone below the surface is shown for each 50 feet, as a guide to the contained water supply.

Benton and Niobrara formations.—The Benton formation, in its typical development, consists of dark shale lying conformably on the surface of the Dakota sandstone. Owing to the heavy drift and loess covers in the region in which the Benton formation should be expected to reach the surface, only one exposure of that formation has been found. This is in the bed of Big Blue River just below Milford, where a few inches of black shales of supposed Benton age are to be seen under the Niobrara beds. As it was not possible to obtain evidence as to the depth at which the Dakota sandstone lies in this vicinity, no definite statement can be made of the thickness of the Benton deposits, but it is thought they will prove to be less than 100 feet thick. The boring at Seward, of which a record is shown in fig. 8, page 31, found 100 feet of dark clay lying between "sand and gravel" and the top of the supposed Dakota beds. If the "sand and gravel" are drillings from Niobrara beds, which is probable, the underlying clay would be Benton. The probable location of the eastern margin of the formation is shown in Pl. XX.

The Niobrara formation is represented by impure siliceous limestones, which outcrop at a number of points in the eastern and southern part of Seward and Saline counties. The beds are usually thin, but owing to their hardness and the ease with which they can be quarried, they have been employed to some extent for foundation and other rough work. There are some quarries near Pleasant Hill, along the west side of the North Fork of Turkey Creek, on the east bank of Big Blue River 4 miles north of Crete, and in the upper portion of the valley of Middle Oak Creek, northeast of Germantown. The formation is also exposed for some distance along Beaver Creek near the southern margin of Seward County, and along Big Blue River just below Milford, notably in a small branch just south of the Soldiers' Home at Milford, as shown in Pl. XI; and it is said to appear in the bed of Big Blue River in the vicinity of Camden.

The rock is characterized by impressions of the fossil oyster known as *Inoceramus labiatus* and possibly some other species. In some of the beds, also, we may expect to find the characteristic fossil *Ostrea congesta*. The general aspect of these fossils is shown in the two figures on Pl. XII. These fossils are here figured because it is very important to be able to distinguish them from the Carboniferous fossils in the limestone which underlies the Dakota sandstone. Their occurrence is a guide to the progress of a deep boring west of longitude 97°, for the water-bearing Dakota beds may be expected in regular order below. The thickness of the Niobrara formation can not be definitely stated, as none of the exposures were complete, and we have no well records which are sufficiently definite to afford a basis for precise estimation. It is believed, however, that the formation will not prove to be over 40 or 50 feet in thickness, and probably it is considerably less.

Pierre shales.—This formation consists of a great mass of shales, predominantly dark gray in color, which thicken rapidly westward under central and western Nebraska. Owing to the heavy mantle of loess and drift, and, to the west, of Neocene deposits, there are no exposures of these shales at the surface. They have, however, been deeply penetrated by a number of well borings. At Kearney it is claimed that they are over 2,500 feet thick; at Hastings they extend from 224 feet to 1,346½ feet; at Dannebrog they extend from 135 feet to 1,011 feet, and at York they were penetrated for several hundred feet. It is probable that the thickness is 4,000 feet under the western portion of the State, as shown in Pl. IV, but the actual amount is not known. The shales contain occasional thin beds of sand, iron pyrites, and heavy dark clay.

Neocene formations.—The representatives of the Neocene formations which are so prominent in the western portions of Nebraska are found underlying the Pleistocene deposits in the central portion of the State, where their thickness gradually decreases until finally they thin out entirely.

EXPOSURE OF DAKOTA SANDSTONE ON ANTELOPE CREEK, IN SOUTHEASTERN PORTION OF LINCOLN, NEBRASKA.
Also shows glacial drift.

The materials consist of siliceous and calcareous sediments, mainly of a sandy texture and chalky aspect. They are often called "magnesia." Portions of the beds are light-colored, very sandy clays containing chalk-like nodules. The eastern margin of these deposits has not been definitely located in the area to which this report relates. South of the South Fork of Loup River there is no evidence of their existence east of longitude 98° 30′, but north of that river they may extend somewhat farther east. They are exposed in depressions northeast of Kearney, and from thence westward in Buffalo, Dawson, Phelps, and Gosper counties, where many of the deeper canyons cut into them. Owing to the manner in which the loess rolls down or caves along the slopes of the wider depressions, exposures are relatively rare, and so far it has not proved practicable to map the Neocene formations very satisfactorily, owing to their being thus concealed for long intervals in depressions in which they might otherwise be expected to outcrop. To the west the exposures increase in abundance and a greater thickness of the formation is exposed. The most extensive exposures in the area to which this report relates are along the upper portions of Plum Creek.

Earlier Pleistocene deposits.—These deposits comprise a mass of glacial drift in Lancaster and eastern Seward counties, and a thin sheet of gravelly sand, which extends far westward under the loess mantle of the plains region, and appears to be contemporaneous with the glacial drift. The glacial drift constitutes a very irregular mass of bowlder clays, sands, gravels, and bowlder beds, covering the greater part of Lancaster County. It constitutes high hills, which are traversed by the deep, wide valleys of Salt Creek and its branches in the region about Lincoln. The glacial drift ends toward the west in the slope which descends quite steeply to Big Blue River from Seward southward. Its precise western limit could not be definitely determined owing to the overlapping of loess and the frequent lack of distinctive outcrops. The greater portion of the glacial drift consists of blue and gray bowlder clays. There are also beds of blue and gray clay nearly pure or containing a little mixture of fine sand, but scattered bowlders of pebbles occur almost everywhere through it. There are included sand beds, ordinarily containing bowlders, but locally quite free from them, and numerous lenses of bowlder beds, consisting mainly of bowlders. The pink Sioux quartzite, often in very large masses, is a conspicuous feature of the drift, but there are many other rocks associated. Wide areas of clay surface with only a few scattered bowlders occur, and other areas of light-colored sandy clays, particularly on the higher, level lands, which appear to be loess merging into the glacial drift. A characteristic bowldery surface is shown in Pl. XIII.

No order of succession has yet been determined for the glacial deposits. Instructive exposures are very rare, and well records have

thrown but little light on the relations. In fig. 4 is given a sketch of some features exposed on the Chicago, Rock Island and Pacific Railroad cut near Prairie Home, in Lancaster County.

The central mass is an oxidized, ferruginous clay of brownish-buff color, with scattered pebbles and soft calcareous concretions. The overlying sheet of bowlders contains many masses of pink Sioux quartzite, mainly angular, with some fragments of other crystalline rocks. This is overlain by pinkish sandy clay, with a few pebbles, mostly of small size. On the top is a mantle of pale-buff loam, with ferruginous and calcareous concretions somewhat like loess in aspect, but more argillaceous and lacking the typical texture.

The thin drift sheet which extends far westward from the glacial-drift margin, under the loess, underlies a wide area of central Nebraska. It is usually a thin sheet of sandy clay, commonly of pinkish color. Eastward it becomes more sandy, thickens, and is often represented by coarse sand. Pebbles of a great variety of rocks of Rocky Mountain origin occur, both in the pink sandy clays and in the more sandy portions to the east. These pebbles are characteristic of the deposit as far westward as I have traced it, which is in the vicinity of Ogal-

FIG. 4.—Glacial formations in cut one-quarter mile west of Prairie Home station; looking north.

lala. The precise relation of this formation to the glacial drift can not be ascertained in the area examined, but it appears to merge into glacial-drift deposits in eastern Seward County.

The loess.—The loess is a great mantle of light buff-colored loam, which constitutes the surface of the plains of south-central Nebraska over thousands of square miles. It abuts against and overlaps the thick mass of glacial drift to the east in eastern Seward County, but extends westward in a vast tabular surface. From the eastward there is a lower-level phase which extends up the depressions of Salt Creek and Little Nemaha River, but does not reach an altitude much above 1,250 feet in the Lincoln region. The most extensive development of the formation is in the wide plains west of Big Blue River, where it covers all of the surface between the large drainage depressions. A wide trench is cut through the formation by the valley of Platte River, and many smaller streams have cut through or deeply into it.

In the upland portions of Buffalo, Dawson, and Gosper counties the surface is deeply invaded by numerous small valleys, which become steep-sided canyons as the land rises to the west, particularly in Gosper County.

DAKOTA SANDSTONE OVERLAIN BY GLACIAL DRIFT, NEAR BENNETT, NEBRASKA.
(LOOKING WEST.)
Shows cross bedding.

The materials of the loess consist of fine sandy loam, somewhat calcareous, and chiefly of a pale brownish-yellow color. Occasionally a streak of sand is found, and some portions are slightly more argillaceous than usual. The material is of remarkably uniform texture, compact, but perfectly soft. Water falling upon its surface is absorbed in some measure, but on steep slopes the material is rapidly excavated wherever a rivulet gets a fair start.

In the lower part of the formation, possibly underlying it and entirely separate, are deposits of volcanic ash, usually mixed with more or less fine sand, but often so pure as to be of brilliant white color, and consisting almost entirely of fine shreds of volcanic glass. The purer material is very serviceable as a polishing powder. The occurrence of this volcanic-ash deposit has been reported at two localities within the area, but owing to lack of knowledge as to the conditions under which it occurs, no description of it will here be offered.

The loess is generally fossiliferous, containing scattered fossils of quite a variety of species, often represented by numerous individuals. These fossils were found throughout the area represented as loess in Pl. III. It also contains calcareous concretions, especially toward the east. An outcrop of loess in Salt Creek Valley is shown in Pl. XV.

Alluvium.—The wider, deeper valleys are floored with alluvial deposits which have been brought from greater or less distances by the streams now occupying these valleys. Along the smaller drainage ways the materials are of such local origin that it has not always been possible to differentiate them satisfactorily, but in the larger valleys they are well-defined alluvial accumulations of considerable thickness. The most notable deposits are those in the wide valley of Platte River, which has a width of 20 miles at Grand Island, 12 miles at Kearney, and 15 miles at Lexington, and is floored to a considerable depth with alluvial deposits.

Along the South Fork of Loup River and Wood River there are also narrower alluvial deposits, which are confluent with those of the Platte Valley. There are deposits also along Little Blue River, Big Blue River and its branches, and in the depression of Salt Creek and its branches.

A large amount of the alluvial deposits consists of loess-like material containing streaks of clay and gravel, but usually lacking the loess texture and fossils. In the immediate vicinity of Platte River, along its channel and islands, the deposits are mainly coarse sands with more or less gravel, but there are extensive admixtures of loam and some clay. In the valley of Salt Creek the material is largely loess-like, but there is also a great deal of dark mud, and this is in greater part the characteristic which is presented along Big Blue River and its larger branches.

Dune sands.—The area to which this report relates lies southeast of the great sand-hill region of Nebraska, but it includes a number of

small local sand-dune areas. The largest of these extends along the south side of the Platte Valley from opposite Elm Creek to opposite Wood River. There are several small dune areas along the south side of the valley of the South Fork of Loup River near Sartoria and Pleasanton, and the southern extremity of an extensive area is found just west of Cairo. There are some small detached areas of dune sands southwest of Kenesaw, in Adams County, and south and southwest of Holstein, in the same county, and in the eastern part of Kearney County. These dune sands are wind blown and derived mainly from alluvial deposits of the river bottom, which have traveled along the valley and accumulated where changes in the trend of the valley were favorable for stopping them, or where some minor obstructions arrested their progress. The belt south of Kearney has a width of about 5 miles where it is widest.

The sands lie on the pebbly or sandy floor of the river bottom, but are usually banked up against the edge of the loess upland, and in some places extend up onto the plains surfaces. The dunes present great varieties of form, cones, ridges, mounds, and basins being the most general. Over much of the area there is no movement of the sand, and the surface is covered with sod. There are, however, many bare places from which the sand is traveling. In windy weather more or less sand is blown all over the region, and loose sand is mixed with the soil of the loess plain adjoining, usually for some distance from the margin of the sand-dune area. A characteristic sand dune is portrayed in fig. 1, on page 13.

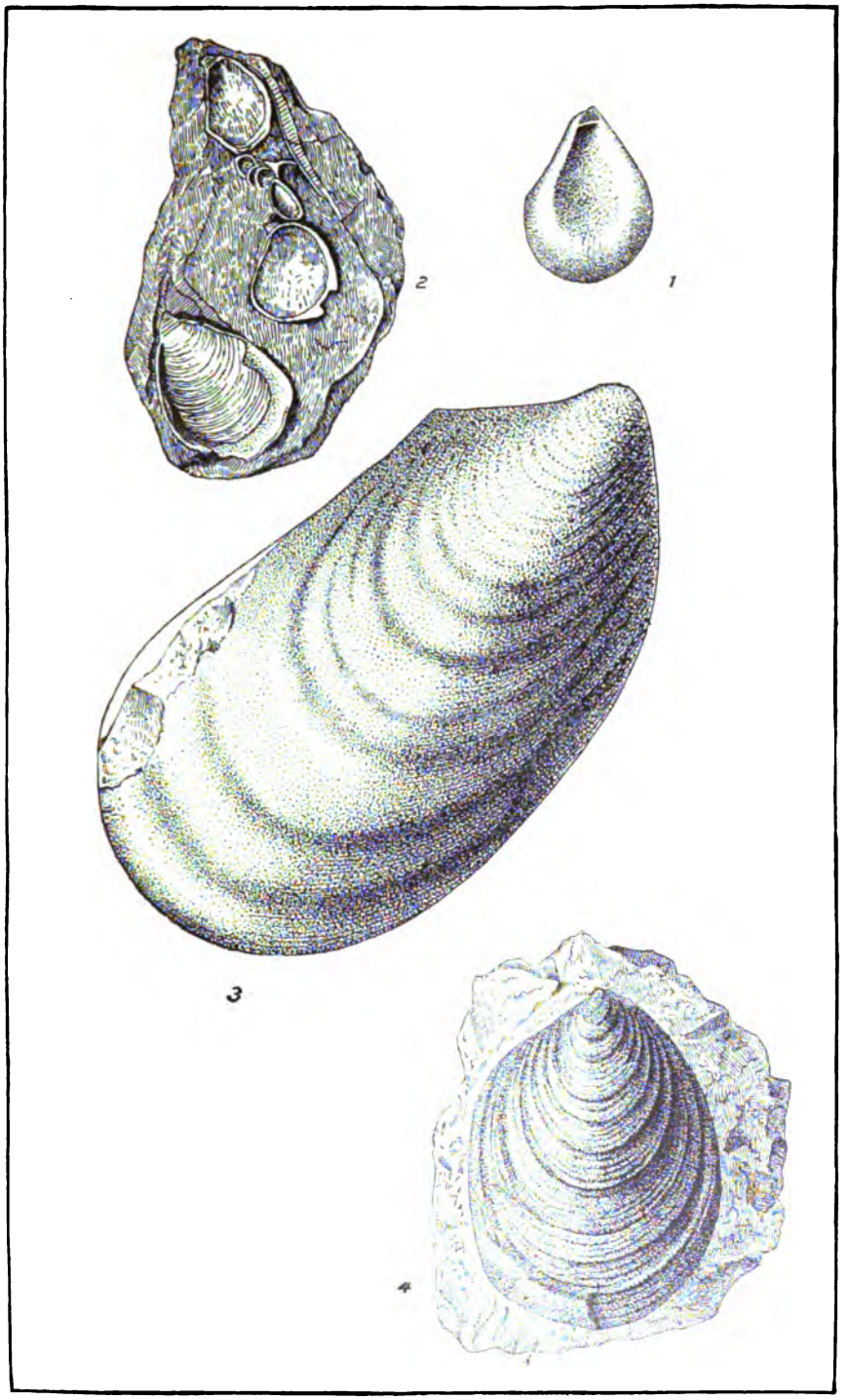
THE WATER HORIZONS.

The underground waters of southern-central Nebraska occur in several geologic horizons. In the region west of Big Blue River the various beds of coarse material lying between the loess and the Pierre shales afford a general water supply which is of large volume at nearly all localities. The eastern edge of the Neocene deposits and the drift sands which lie just below loess are the principal reservoirs of these waters.

In the wide valley of Platte River nearly all of the coarser materials, especially the basal beds of the alluvium and the coarser portions of the alluvium near the stream, are filled with water, which is obtainable from shallow wells. Although in dry weather the Platte River shows very little water at the surface, just below the dry sand and shingle in its bed there is a sheet of water which extends widely under the alluvial flat on either side. These permeable alluvial materials and more or less underlying coarse material of Neocene and Pleistocene age contain a large aggregate supply of water.

As the valley of Platte River is somewhat higher than the adjoining valleys of the branches of Blue, Republican, and Loup rivers, the waters that lie in its bottom flow out laterally through the coarse mate-

NIOBRARA LIMESTONE ON COON CREEK, IN SOUTHERN PORTION OF MILFORD, NEBRASKA. (LOOKING NORTH.)



TYPICAL FOSSILS OF NIOBRARA LIMESTONE.

Ostrea congesta Conrad. { Fig. 1. Interior view of the upper valve, slightly enlarged (after Meek).
Fig. 2. Three small lower valves attached to the shell of a large Inoceramus (after Meek).

Inoceramus labiatus Schloth. { Fig. 3. Right valve of an elongated specimen (after Meek).
Fig. 4. Small right valve with unusually strong concentric ridges

rial underlying the loess and issue as springs or underground seepage in these deeper depressions. In the vicinity of Grand Island the evidence is very clear that the Platte waters pass under the loess-covered divide and emerge in the deep valleys of the head waters of branches of Big Blue River, which are considerably lower in altitude than the bottom of the Platte Valley. There is also underground leakage to the north into the depression containing the South Fork of Loup River. This is very clearly shown at Kearney, where, in a series of gage wells sunk for the Division of Hydrography, the water level is shown to gradually decline to the northwest a very appreciable amount within the city limits of Kearney, as shown by fig. 12, on page 40. The wells in the valleys and high lands northward show a continued diminution in altitude of the water surface, which indicates an underground flow to the north. There is excellent evidence that under Phelps and Kearney counties there is underflow from Platte River toward the Republican Valley. This underflow is rendered possible by the pervious nature of the great sheet of materials which lies between the loess and the top of the impervious Pierre shales. These conditions are illustrated in fig. 5.

FIG. 5.—Ideal section showing the usual relations of underground waters in the central plains region of Nebraska.

The valley on the left is that of Platte River, and the depression on the right is similar to the depressions of the branches of Big and Little Blue, Republican, and Loup rivers. The rate of this underflow is exceedingly slow, for careful experiments have shown that underground water moving through sands, even if the sands are relatively coarse, does not progress over a mile or two a year.

As the water-bearing beds under the loess thicken westward, their upper portions rise higher above the bottom of the Platte Valley in western Dawson and Gosper counties, and it is usually found necessary to go to considerable depth in them to find sufficient water supply.

Some of the exceptional relations which are often found locally in the region west of the ninety-eighth meridian are illustrated in the cross sections in Pl. XVIII. In section *A* there is shown a condition which is quite frequent in Buffalo and Dawson counties. A well at B has to go to the general underflow in the water-bearing bed A A; but at C, at much less depth, a local water supply of greater or less volume is found in a shallow basin underlain by clay. In section *B* a condition is illustrated which is found in some of the shallower valleys on the high loess plains. Here the underflow conditions are continued

under a valley without interruption, and the beds yield water to wells at G G. They are also reached by wells at E and F, but at E a water supply may be obtained from the gravels flooring the valley bottom. In section *C* are shown the relations of two water-bearing sands separated by a bed of clay. In some areas both horizons are drawn on for water, and either one may contain the greater amount. Ordinarily the deepest wells obtain the largest supplies of water, but in other cases the largest volumes are in the upper bed of sand containing the underflow from the river valleys. A well at H would find abundant supplies of water in the gravels and sands flooring the valley.

Section *D* illustrates a relation which may account for some observed inequalities in the volume of water in the same bed of sand on either side of a river valley. A well at J would yield a good supply of water, but one at K would yield less because the water escapes into the river bottom on the one side and a local deposit of clay seals off the entrance of a continued underflow on the other side of the valley toward K.

Section *E* illustrates a change of material from coarse to fine—pervious to impervious—in the same bed. Thus, a well at L would

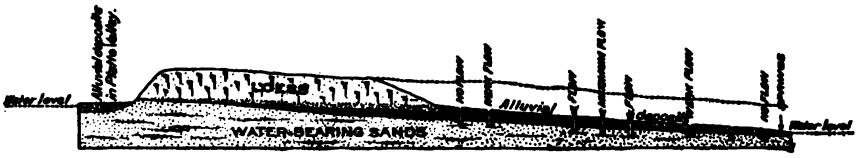


FIG. 6.—Ideal section from the Platte Valley to and down the valley of West Blue River, to show the probable cause of the flow.

obtain a water supply from sands which merge into clay toward M, where the clay would have to be penetrated to underlying sands at greater depth.

The geologic relations of the water-bearing stratum in the Beaver Crossing region are not as yet fully ascertained. The waters lie in sands which are overlain by a heavy bed of tough, impervious clay, but the depths are so moderate that it can hardly be thought that these sands are of the Dakota formation. It is much more probable they are in the western extension of the drift deposits. The head is due to the elevation of the intake area of the waters westward, and it is sustained locally through the protection afforded by a wide extent of the overlying mantle of tough, impervious clay. In fig. 6 is given an ideal section to show the probable relation. This should be compared with the section in fig. 5 (p. 25), which shows the usual conditions in other areas where there is no flow.

In Lancaster and eastern Seward counties the principal supplies of underground waters occur in the Dakota sandstone and sands. In the drift deposits waters are often abundant in supply and satisfactory in quality, but their occurrence is so exceedingly irregular that

TYPICAL STONY DRIFT SURFACE, NORTHERN LANCASTER COUNTY, NEBRASKA.

no definite idea could be formed as to their relations. A large number of wells have been sunk to the Dakota sandstone, which is usually so porous as to yield an excellent water supply. In the lower lands it lies at very moderate depths, but in the higher lands a deep boring is often required to reach it. On account of the definiteness of this water horizon it has been made the basis of water prediction in the Lancaster County area, as shown on Pl. XVII.

The waters of the Carboniferous limestone have been tested at Lincoln, and found to be highly saline. In a portion of this area the waters in the Dakota sandstone, also, are quite saline, owing, it is thought, to impregnation from springs or seepage from the underlying Carboniferous limestone. It is probable that these springs existed during the deposition of the Dakota formation, and have continued in greater or less volume since, for the present superficial deposits of the valley are highly impregnated with salt.

In the sand hills, especially those in northern Kearney and northeastern Phelps counties, more or less water is often found in the base of the sand accumulations, especially where the sand lies on a less permeable portion of the alluvial deposits. Quite a number of shallow wells in the sand-hill region find a satisfactory domestic supply of water without having to sink to the underlying alluvium or loess.

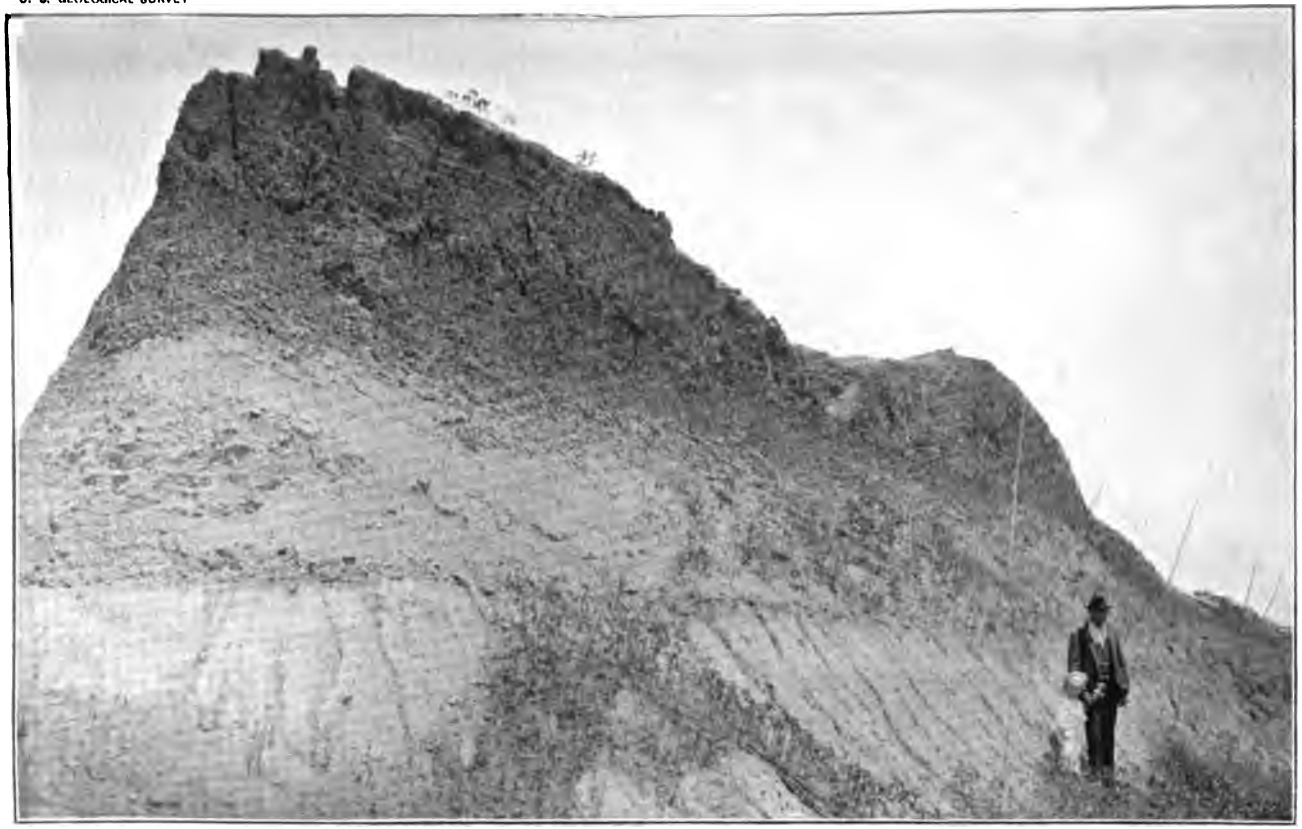
LANCASTER COUNTY.

Lancaster County lies within the area of glacial drift, which is underlain mainly by the Dakota sandstone. There are also wide valleys, mainly those of Salt Creek and its branches, filled with loess and alluvium. The principal water-bearing formation is the Dakota sandstone, but waters also occur among the drift deposits. The waters in the drift are of very irregular occurrence, but they furnish supplies for many scattered wells. As their distribution is governed by laws at present not well understood, it is almost impossible to make a general statement regarding them which would be of any value. In some cases, also, waters supposed to be derived from the drift may possibly accumulate through leakage from the underlying Dakota sandstone. This sandstone appears to carry water supplies throughout the area of Lancaster County, excepting about Roca and along the Little Nemaha River, where the limestones come to the surface, and at a few local points where the rock is less permeable than usual. The surface of the Dakota sandstone slopes, as a rule, gently eastward, although the general dip of the beds of the formation is toward the west. The contour of its surface under the heavy drift mantle is by no means regular, for it presents numerous ridges and mounds of various sizes, separated by irregular depressions, as shown in Pls. XX and XXI. The larger depressions of the county have been excavated through the drift, and in places more or less deeply into the Dakota formation, which gives further complexity to the contour of its surface.

As the Lancaster County region is one of high hills and ridges, the irregular surface of the Dakota sandstone lies at depths which vary greatly. These variations, however, are not too irregular for representation on a map, and in Pl. XVII there is shown the depth to the surface of the sandstone for each 50 feet from 50 to 250 feet. This representation is based on observations of the outcrops, which give a fairly good idea as to the surface configuration of the formation, and on the records of numerous wells which draw their waters from it. It will be seen that the depths are quite closely related to the altitude of the land above the principal valleys, and that there is also a somewhat general increase of depth to the north and northwest. In the area in which waters are shown to be obtainable at less than 50 feet below the surface the supplies are derived mainly from the Dakota sandstone, into which the depressions are excavated. In many portions of these depressions waters are available at considerably less than 50 feet below ground, but there is great irregularity in this regard.

The water supplies for the city of Lincoln are obtained from three pumping stations within the city limits. The Rice well, at Twenty-fourth and N streets, has a main well 50 feet deep and 40 feet in diameter. In its bottom there are seven wells 6 inches in diameter and 140 feet deep, from which the water flows up into the large well to within 15 feet of the ground when the pumps are not in operation. The water is almost perfectly fresh. The supply is augmented by six 6-inch gang wells, 140 feet deep, situated 150 feet south of the main well. The total product is stated to be 200,000 gallons a day. At the Park well, on F street near Sixth, there is a 50-foot well 75 feet in diameter. It contains three 6-inch tubular wells 40 feet deep. The water, which is somewhat salty, rises to within 10 feet of the ground, and the supply is 200,000 gallons a day. At South and Seventh streets there is a supplemental plant, from which the water is quite salty. It consists of a gang of 24 points, 55 to 58 feet deep, 4 inches in diameter, and yielding 150,000 to 200,000 gallons a day. The salinity of the waters used by the city of Lincoln from these three plants increases gradually from east to west toward the center of the salt-marsh area which lies along the western margin of the city. As the Dakota sandstone contains abundance of fresh water to the east and north of Lincoln it seems quite unnecessary that the city supplies should be in part drawn from the salt-basin area. Several deep borings made in Lincoln and vicinity obtained only salt waters. They passed through the Dakota sandstone, which furnishes the waters for the shallower wells, far into the Carboniferous limestones and underlying formations. The record of the well sunk by the State at the southern edge of the Salt Lake, now Burlington Beach, is given in fig. 7. This record was drawn mainly from the statements published by Mr. B. P. Russell,[1] the geologist who was placed in charge of the well.

[1] Sixth Biennial Report of the Commissioner of Public Lands and Buildings to the Governor of Nebraska, December 1, 1888, pp. 57-84.



GLACIAL DRIFT ON DAKOTA CLAY IN PITS SOUTHWEST OF INSANE ASYLUM NEAR LINCOLN, NEBRASKA.

LOESS ON GLACIAL DRIFT AND DAKOTA CLAY IN CLAY PITS SOUTHWEST OF INSANE ASYLUM NEAR LINCOLN, NEBRASKA.

Loess extends to level of tramway, which is on the thin layer of glacial gravel.

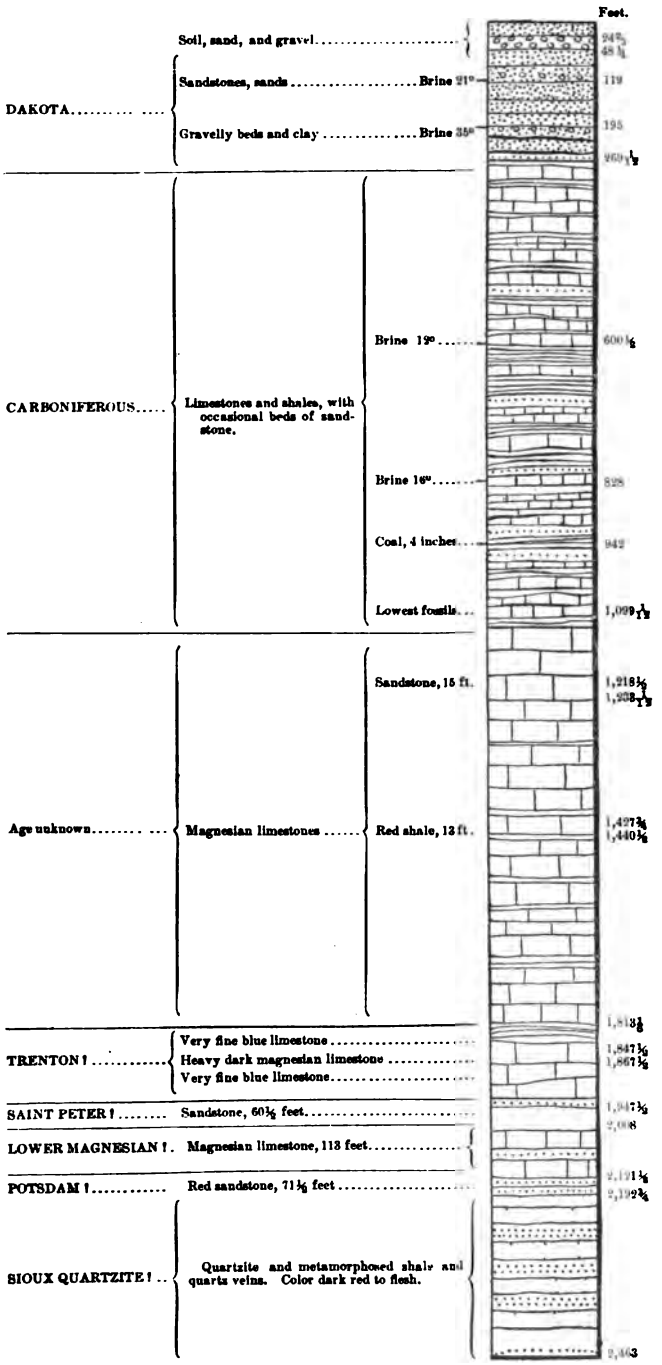


FIG. 7.—Section of salt well 1 mile west of Lincoln, Nebraska.

The borings were deposited in the museum at the State University, in Lincoln. So far as can be judged, the Dakota sandstone began at a depth of about 48 feet and extended to a depth of 269 feet 1 inch. The clays at 208–214 feet, and the sandstone at 214–244 feet and 248–267 feet appear to be typical Dakota beds. The principal flow of water is from a reddish sandstone in the Carboniferous limestone at 600 feet. It is very saline. A similar flow is obtained at a depth of 570 feet at the sanitarium in Lincoln, and at 560 feet in the 1,050-foot well in the Post-office Square. In the State well another saline flow was found at 828 feet. The head of the water at the sanitarium is about 1,210 feet above sea level, its pressure being 15 pounds to the square inch.

SEWARD COUNTY.

The wells of Seward County draw their supplies from several sources. In the valley of West Blue River, in the vicinity of Beaver Crossing, there is a considerable area in which artesian flows are obtained. In the adjoining plains region the water is in gravels and sands underlying the loess. In the drift hills east of Blue River, waters are found in sands among the drift deposits and also in the underlying Dakota sandstone; and in the valleys of Big Blue River and some of its branches there are waters in the basal portions of the alluvial beds and in the underlying sands and gravels in which the valleys have been excavated. In most areas the supply of water found is very abundant, but at some points in the drift hills and about Seward the volume is small, so far as now developed.

The artesian area in West Blue Valley has been extensively explored by many wells. It begins about 6 miles below Beaver Crossing and extends to the western margin of the county on Beaver Creek and some distance into York County, up the South Branch Valley. Laterally the area of flow is limited by the lower slopes in the valley. About Beaver Crossing the head is sufficient to afford a flow to from 18 to 23 feet above the bottom lands. The head gradually diminishes up and down the valley as the ends of the artesian area are approached. The wells vary in depth from 90 to 140 feet, the shallower ones drawing from an upper stratum of water-bearing beds known as the "first flow." In Beaver Crossing the wells are mainly from 102 to 110 feet deep. The water is obtained from a bed of sand which lies under a sheet of clay extending from 40 to 90 feet. The wells in this artesian area are of various sizes, from 1 inch to 4 inches in diameter. The flows vary from 10 to 150 gallons a minute. The supposed geologic relations in this artesian area are shown in fig. 6, page 26.

It is said that flowing wells have been obtained at Ruby, and in one of the attempts to find deep-seated waters near Seward. The water at Seward was found at a depth of 336 feet, and, it is claimed, flowed out of a pipe 12 feet above ground, but only in small volume. This boring was four blocks east and four blocks south of the court-

RECENT VALLEY DEPOSITS ALONG SALT CREEK, IN EASTERN PORTION OF LANCASTER COUNTY, NEBRASKA.

penetrated the Dakota sandstone for 40 feet, but found it exceedingly hard and almost dry. This, however, appears to be a very exceptional condition.

NORTHERN SALINE COUNTY.

Only the northern half of this county was included in the area examined in 1896. It is a region in greater part of plains, traversed by the North Fork of Turkey Creek, and, near its eastern margin, by Big Blue River. East of the wide alluvium and loess plain in the valley of this river rise the slopes of the hills of glacial drift which are so prominent in the adjoining county of Lancaster. The underground waters which supply the plains region are found in a sheet of sand and gravel which underlies the loess. This water-bearing stratum lies between 60 and 90 feet below ground over the greater part of the plains portion of the county, and yields water to a large number of wells. At Friend the water level is 90 feet below ground. At Dorchester the town well is 110 feet deep, and the water rises to within 98 feet of the surface of the ground.

Along the valley of Turkey Creek and Big Blue River water supplies of greater or less amount are obtained at depths mainly of 30 to 40 feet. The shallower wells at Crete have a depth of about 40 feet, with a water surface 15 feet below ground. In deep wells, sunk for larger supplies for the city, a depth of 155 feet is attained, probably to the top of the Dakota sands. The wells contain 139 feet of water, the water level being 16 feet below ground. On the slopes of the drift hills east of Blue River the waters occur in a very irregular manner. Many of the wells are between 40 and 80 feet in depth, and obtain satisfactory water supplies. Other wells have been sunk to depths of from 120 to 180 feet, notably in an area at the head of Salt Creek, 4 miles southeast of Crete.

The Dakota sandstone underlies this county at no great depth, and might be expected to furnish water supplies, but few attempts have yet been made to reach the formation, as usually sufficient water for local use has been obtained in overlying deposits.

YORK COUNTY.

The greater part of York County is underlain by formations containing large supplies of water, which are in greater part available for wells less than 100 feet in depth. In two small districts on the higher plains the depths to the waters are slightly over 100 feet. These are south of McCool and on the north side of Lincoln Creek north of Bradshaw, where the wells are from 110 to 140 feet in depth, and contain from 10 to 30 feet of water, bringing the water level not much more than 100 feet below ground.

In the depressions of Blue River and its branches and of Beaver and Lincoln creeks it is only necessary to sink from 20 to 40 or 50 feet for abundant water supplies, which come from the same water-

97°

Lancaster C

allow wells (fr

the ground.

feet deep.

" "

" "

" "

" "

" "

" "

are of very uncer
rea

97°

bearing beds as those which lie at greater depth beneath the higher lands. The greater number of wells in York have a depth of about 35 feet and contain 12 feet of water. In the higher land in the northern part of the town the waters lie about 30 feet deeper.

The following are a few representative wells of York County:

Wells in York County.

Locality.	Depth.	Depth of water in wells.
	Feet.	*Feet.*
McCool	15–25	2–5
Lushton	110	20
Charleston	80	
Henderson	94	7
Bradshaw	90–106	4
Benedict	100	15–20
Graham		
Waco town wells	120	30
Waco	102	8–10

In the wide plain between McCool and York the water surface averages about 80 feet below ground, but it presents some slight variations. The greater number of the wells are from 80 to 100 feet deep. At Lushton another bed of water-bearing material also occurs, at a depth of 65 feet. On the plains between Beaver Creek and Turkey Creek the wells are 85 feet deep, and contain 15 feet of water. At Houston the water does not rise above the gravel in which it is contained.

North of Lincoln Creek the conditions are somewhat more variable, but the greater number of wells obtain abundant supplies of water, which rises to within 80 feet of the surface of the ground. In Arborville, which is on relatively low land, the town wells are 35 to 50 feet in depth, and the water rises to within 30 feet of the surface of the ground. In the adjacent higher lands the wells are from 50 to 100 feet in depth. At Waco the water rises 4 to 5 feet above the point where first reached.

The western extremity of the Beaver Crossing artesian area extends up the lowlands in the valley of South Branch of Blue River, in the extreme eastern part of this county. There are only a few flowing wells, but they obtain a fair supply of water from depths varying from 110 to 134 feet. Ascending the river, one finds the head gradually decreasing until no flow is obtainable; descending, an increased head is found, which at its greatest is sufficient to give a flow at 10 feet above the level of the bottom land.

Some years ago an attempt was made to obtain an artesian flow just south of York, at the Russian mill, where a depth of 590 feet

was attained. It is stated that a flow was found at a depth of 530 feet, which spouted 2 feet above the top of a tube extending 14 feet above ground; but this statement could not be authenticated satisfactorily. A small flow was reported at 290 (or 390?) feet. There also appears to be uncertainty in regard to the record of the boring, but according to the most consistent statement, there was fine-grained material to 93 feet, sand and gravel from 93 to 100 feet, shale from 199 feet for a considerable depth, and sandstone at the bottom, in which the drill stuck at a depth of 590 feet. The sandstone may possibly be the Dakota formation.

A deep boring was started at McCool, but it was abandoned at a depth of 150 feet. The following record was furnished by Mr. D. C. Kims, the borer:

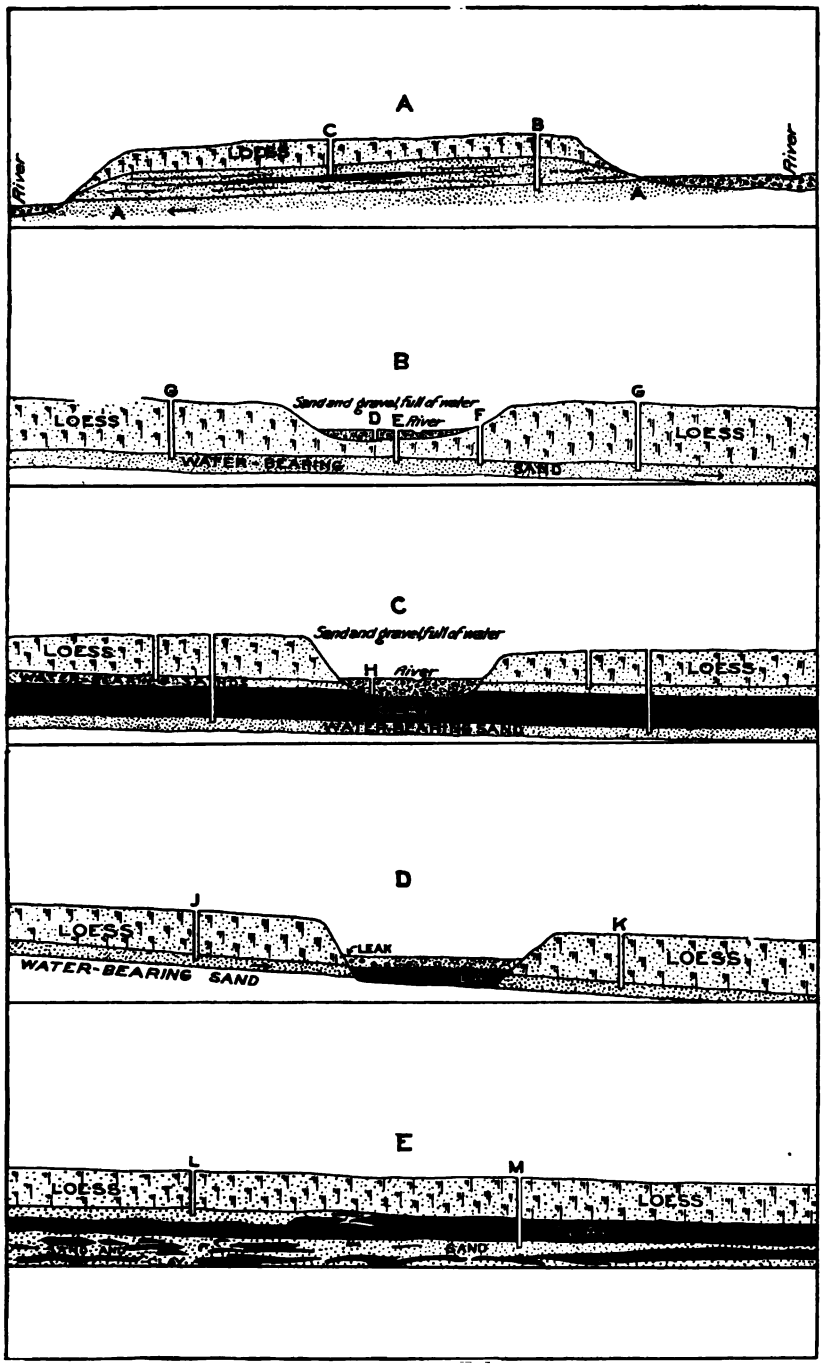
Feet.	
0– 30	Loam.
30	Water.
30– 70	Sand.
70–100	Yellow clay.
100–107	Soft white rock.
107–118	Blue sand and water.
118–150	Tough blue clay, with a 2-foot rock layer.

FILLMORE COUNTY.

In this county the conditions are very similar to those of York County. There are fewer deep valleys, and over the wide, level plains area the wells find abundant water supplies, which usually rise to within from 60 to 90 feet of the surface of the ground. Some of the wells have gone deeper to secure larger volumes of water, but the level to which the water rises is nearly constant over the area. Some representative wells are as follows:

Wells in Fillmore County.

Locality.	Depth.	Depth of water in wells.
	Feet.	*Feet.*
Fairmont	30–70	15–20
Railroad station	237	157
Geneva	120	35
Sawyer	65–75	12–20
Sutton, city supply	140	60
Saronville, town wells	80	15
Strang	80–100	15–30
Exeter	40	15
Martland	96	5
Shickley	85–100	5–10



SECTIONS ILLUSTRATING SOME SPECIAL CONDITIONS AFFECTING UNDERGROUND WATERS IN SOUTH-CENTRAL NEBRASKA.

A record of the well at the railroad station at Fairmont is given in fig. 9.

Some tubular wells in the neighborhood of Saronville are from 140 to 150 feet deep, with large volume of water. At Exeter the water-bearing beds are exceptionally near the surface of the ground.

HAMILTON COUNTY.

This county comprises a wide area of plains, its northwest corner extending, however, part way across Platte Valley. It is underlain by a sheet of water-bearing gravels and sands that are exposed in the deep valleys of several branches of Blue River which traverse the central and eastern portions of the county. On the plains surface lying between these valleys the water-bearing stratum is covered with loess to depths of from 50 to 80 feet. In the valley of Platte River the principal water supplies are in the alluvial gravels and sands at depths less than 25 feet.

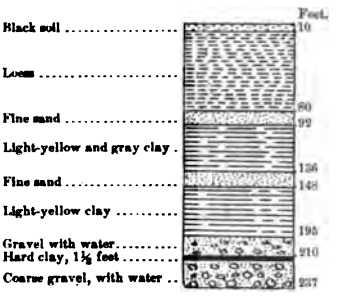


FIG. 9.—Record of deep well at Fairmont, Nebraska.

In the greater part of the plains area the water-bearing beds lie from 60 to 90 feet below ground. In a few small areas about Aurora and northwestward the water level lies deeper than 100 feet, but, so far as ascertained, good supplies are always obtainable within 125 feet of the surface, the water usually rising to within 100 to 110 feet of the surface of the ground. At Aurora the principal wells have a depth of 110 to 125 feet, with the water level 100 feet below ground. About Bromfield (Giltner post-office) the wells average from 75 to 95 feet in depth and generally contain from 6 to 15 feet of water. About Phillips the water level averages about 90 feet below ground. At Marquette the wells vary in depth from 100 to 130 feet. The town well is 130 feet deep, and the water rises to within 97 feet of the surface of the ground. In another well, 105 feet deep, the water level stands within 99 feet of the surface. At Hampton wells average from 85 to 105 feet in depth, with the water level at about 80 feet below ground. In the valley of Platte River the water level lies from 5 to 8 feet below ground in the vicinity of the river and for a mile and a half westward, beyond which for a wide area the water level seldom exceeds a depth of 15 or 20 feet below ground. In the depressions along the branches of Blue River which traverse the central and eastern portions of this county there are usually excellent water supplies to be had within 30 or 40 feet of the surface, and there is considerable running water in the stream, derived partly from the outcrops of water-bearing beds which furnish supplies of water for the moderately deep wells on the higher lands.

CLAY COUNTY.

This county lies altogether on the high plains, and wide areas of its surface have only a gentle, uniform slope toward the east. In the northern portion of the county there are broad troughs cut by branches of the South Branch of Blue River, and the southwestern corner of the county is crossed by the valley of Little Blue River. The relations of the underground waters are very simple, the water-bearing stratum consisting of gravels and sand lying beneath the loess and dipping gently eastward at a rate very little less than the slope of the plains surface. The water level is about 60 or 70 feet below ground over wide areas, and it is rarely necessary to sink a well to a depth of more than 120 feet to obtain an abundant supply. A large number of wells have a depth slightly less than 100 feet and contain from 10 to 15 feet of water. In the vicinity of Inland and Trumbull there are a few wells in which the waters lie a little deeper than 100 feet.

In the depressions of Little Blue and the branches of Big Blue rivers, waters are obtainable at depths of 20 to 40 feet in greater part. At Fairfield the wells vary from 80 to 100 feet in depth and contain large supplies of water, which rises about 10 feet above the bottom.

At Harvard the wells are generally slightly less than 100 feet deep, but a few have gone somewhat deeper to obtain larger volumes of water. At Clay Center the wells average 100 feet in depth, with the water level at about 85 feet below ground; at Inland, 120 feet, with the water level 110 feet; at Trumbull, 115 to 120 feet, with the water level 110 feet; at Glenville, 103 feet, with the water level 97 feet; at Saronville, 80 feet, with the water level 65 feet; at Sutton, 140 feet, with the water level 80 feet. At Deweese the wells average from 40 to 50 feet in depth and contain from 10 to 15 feet of water. At Edgar the wells are 88 feet deep, with 8 feet of water. At Ong the wells average 80 feet deep, with from 1 to 3 feet of water.

HALL COUNTY.

The greater part of this county lies in the valley of Platte River. In its southwestern corner there is a level area of plains country 60 to 80 feet higher, and in the northwestern corner an area of plains ridges and sand dunes, with the valley of the South Fork of Loup River beyond.

In the wide valley of Platte River the relations of the underground waters are very uniform. The supplies are large and the depth to the water surface is very slight. In the immediate vicinity of the river there is a narrow belt of country in which the water level is less than 10 feet below ground. About Grand Island and westward it lies from 15 to 20 feet deep in greater part, but in some of the lower areas it is nearer the surface of the ground. In the plains region about Doniphan and southwestward the waters lie between 60 and 100 feet

SPRING FROM DAKOTA SANDSTONE ALONG MISSOURI RIVER NEAR MOUTH OF PLATTE RIVER, SARPY COUNTY, NEBRASKA.

below ground, the depth increasing somewhat in the higher land west of Hansen. The tubular wells in this vicinity are usually sunk to a depth of 130 feet, but have the same water level as the shallower borings. In the higher ridges southwest of Cairo the wells ordinarily obtain satisfactory water supplies, but have to be sunk to a depth of 120 to 140 feet. At the waterworks in Grand Island there are thirty-six 2-inch driven wells, 54 feet deep, in which water rises to within 16 feet of the surface of the ground. There are pumped from these wells 1,000,000 gallons per day. Moderate supplies of water are found within 20 feet of the surface, but it was necessary to go considerably deeper to obtain the town supply.

About Abbott the wells are from 25 to 40 feet deep, with the water level at about 18 feet below ground. At Cairo the wells on the higher land are 60 feet deep and contain 35 feet of water.

In the Loup Valley the conditions are similar to those in the Platte Valley eastward.

ADAMS COUNTY.

The underflow from Platte River passes southeastward under Adams County through sands and gravels which present everywhere relatively uniform relations. The waters are more or less free to escape into the valley of Little Blue River, which quite deeply trenches the plains region in the southern portion of this county. The depth to the waters varies closely in relation to the altitude of the land, making due allowance, however, for the uniform slope of both the land and the water-bearing beds to the east and southeast.

In the higher portion of the plains separating the valley of Platte River from that of Little Blue River the water level lies between 100 and 125 feet beneath the surface over considerable areas, as shown in Pl. XVII. On the less elevated areas adjacent, the depths are considerably less—usually from 60 to 80 feet; while in the valley of Platte River, in the extreme northwestern corner of the county, and in the depressions of Little Blue River and its branches to the south, the waters are very near the surface of the ground. At Hastings a large supply of water for city use is obtained from seven wells sunk to a depth averaging 140 feet and containing about 20 feet of water. An attempt was made to obtain water from a deeper source (300 feet), but the 120-foot horizon was found to be the most serviceable.

Some years ago a deep boring was made at Hastings for oil or gas, which has thrown some light on the deeper underground geology of the region. A record published by W. W. Follett[1] is here reproduced in graphic form in fig. 10 (p. 38).

From another authority it was learned that the total depth was 1,346½ feet, the lower 370 feet being reported as "soft shale limestone,

[1] Report on Irrigation, 52d Cong., 1st sess., Senate, Ex. Doc. 41, Part II, Washington, 1893, Pl. XXV.

sand, and gravel, with seashells at 1,300 feet." Hard limestone 1½ feet thick was reported at 775 to 776 feet, soft limestone and shale from 776 to 801½ feet, and light shale and lime rock from 930½ to 976½ feet. The shale was stated to be hard from 250 to 500 feet and soft from 500 to 775 feet.

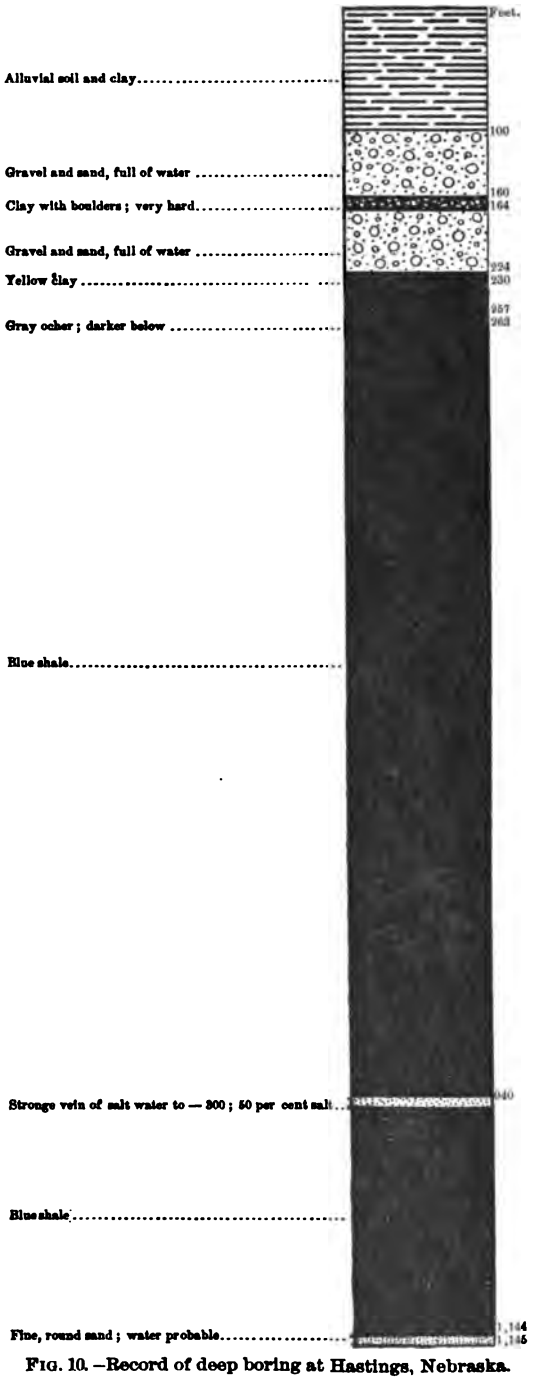
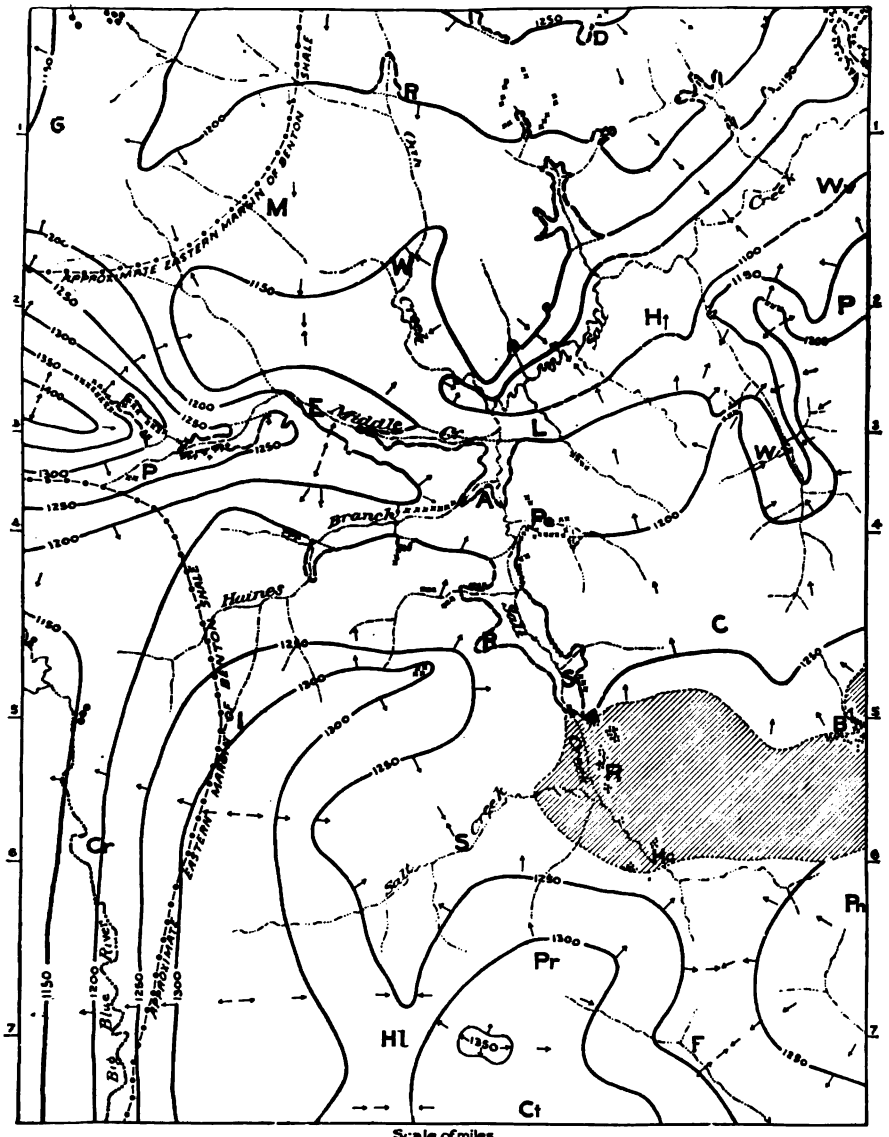


FIG. 10.—Record of deep boring at Hastings, Nebraska.

At Juniata wells are of somewhat variable depth, but they average slightly less than 100 feet and contain about 10 feet of water. At Kenesaw, wells from 90 to 115 feet deep have their water level at about 80 feet below ground. At Prosser the town well has a depth of 115 feet, with the water level 112 feet below ground, slightly deeper than in the adjoining region to the north. At Hansen the water level lies about 70 feet deep. At Roseland the wells average from 80 to 105 feet in depth, with the water level about 80 feet below ground. At Holstein the wells are 130 feet deep, and contain 25 feet of water. At Pauline wells vary from 85 to 105 feet, with the water level at from 80 to 90 feet, depending upon the proximity to Little Blue River. At Ayr a fairly satisfactory supply of water is found at a depth of 30 feet, which rises but little above the bottom of the boring, and the supply varies with the weather.



MAP SHOWING CONTOUR AND RELATIONS OF SURFACE OF DAKOTA SANDSTONE IN THE VICINITY OF LINCOLN, NEBRASKA.

The heavy black lines indicate altitudes above sea level of the surface of the Dakota sandstone. The broken lines indicate depressions cut in this surface since the Glacial period, the dotted lines showing the original configuration. The arrows point to the direction of slope. Present drainage shown by broken-and-dotted lines.

L	Lincoln.	W.	Woodlawn.	B.	Bennett	Hc.	Hickman.
E.	Emerald.	xxP.	Pleasantdale.	Pn.	Panama.	A.	Asylum.
Sx.	Saltillo.	Cr.	Crete.	G.	Germantown	Pe.	Penitentiary.
Wv.	Waverly.	M.	Malcomb.	Hl.	Hallam	H.	Havelock.
Pr.	Princeton.	D.	Davey.	R.	Rokeby	P.	Prairie Home.
Ct	Cortland.	R.	Raymond.	S.	Sprague.	W.	Walton.
F.	Firth.	C	Cheney.				

BUFFALO COUNTY.

Buffalo County comprises portions of the Platte and Wood River and South Fork of Loup River valleys, with wide areas of intervening high plains. The depths of the underground waters are closely related to the altitude of the land above Platte River, the water-bearing strata sloping eastward at about the same degree of inclination as the slope of the general surface. As the valley of South Fork of Loup River is somewhat lower than the bed of Platte River, and there are beds of permeable material extending under the high plains from one to the other, there is a sheet of water under Buffalo County which is probably moving toward the northeast. This sheet of water furnishes a large volume to many wells in all parts of the county. Immediately along Platte River the wells are very shallow, the water rising to within from 5 to 9 feet of the surface of the ground. This area of shallow wells widens considerably in the vicinity of Gibbon, and extends for some miles, nearly to the Union Pacific Railroad. At Gibbon the water level is within 10 feet of the surface and furnishes large supplies to wells from 25 to 35 feet in depth.

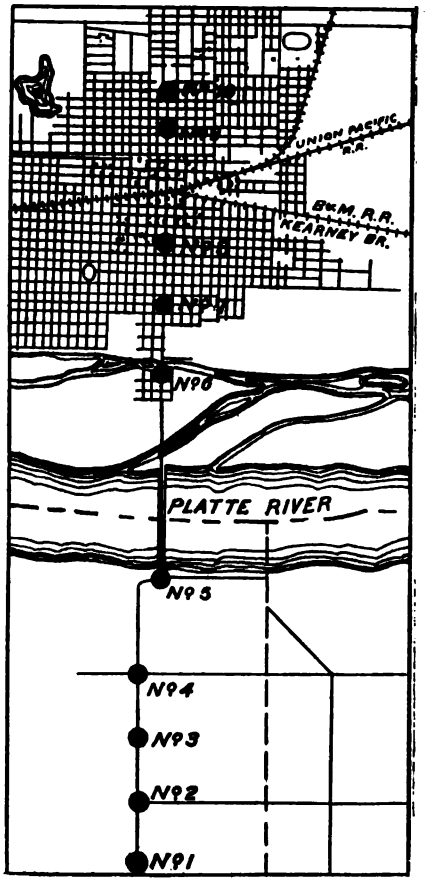


FIG. 11.—Map showing location of gage wells at Kearney, Nebraska.

Next north of this zone and occupying the remainder of the wide valley of Platte River, with an extension up the valley of Wood River, there is a wide area in which the water surface lies between 15 and 40 feet below ground, and similar conditions exist along the valley of the South Fork of Loup River. At Kearney the principal supplies of water are obtained 20 feet below ground in wells from 25 to 35 feet deep in greater part, the depth increasing somewhat and the altitude of the water surface decreasing notably from south to north across the city.

At Odessa wells are 20 feet deep; at Elm Creek 14 feet. At Riverdale, in Wood River Valley, wells 102 feet deep contain 77 feet of water, but other shallower wells in the vicinity have water at the

same level. At Amherst the water level is 25 feet below ground. At Watertown the wells are 85 feet deep. At Miller the town wells are 73½ feet deep and contain 40 feet of water. At Sartoria wells are 22 feet deep and contain 12 feet of water. At Pleasanton they are 15 feet deep. At Ravenna it is found necessary to go to a depth of 60 feet for a good flow, but the water rises to within 20 feet of the surface. Surface waters of relatively poor quality are found at a depth of 30 feet, which rise to the same level.

Over the greater part of the ridge south of the South Fork of the Loup River the water surface is generally from 100 to 150 feet below ground toward the valleys. Along the central ridge north of Amherst is a tract in which it is found necessary to go somewhat deeper, the wells having a depth of 170 to 250 feet, with the water level about 150 feet below ground. In the ridge extending northwest of Kearney between the Platte Valley and the valley of Wood River the conditions are similar to those in the land north of Wood River, and they are the same along the northern edge of the county, north of the South Fork of Loup River.

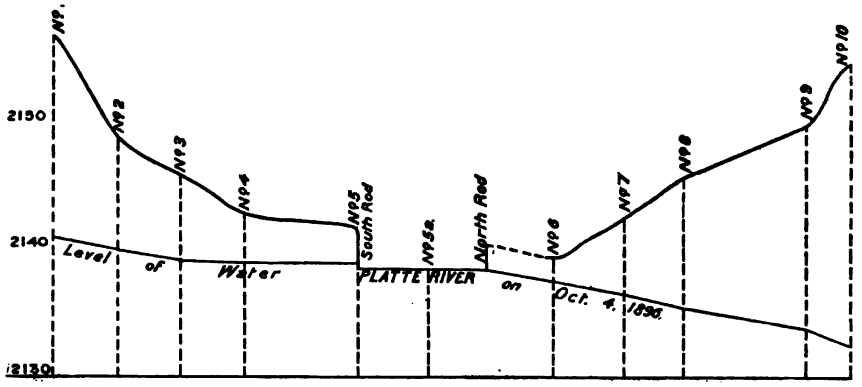
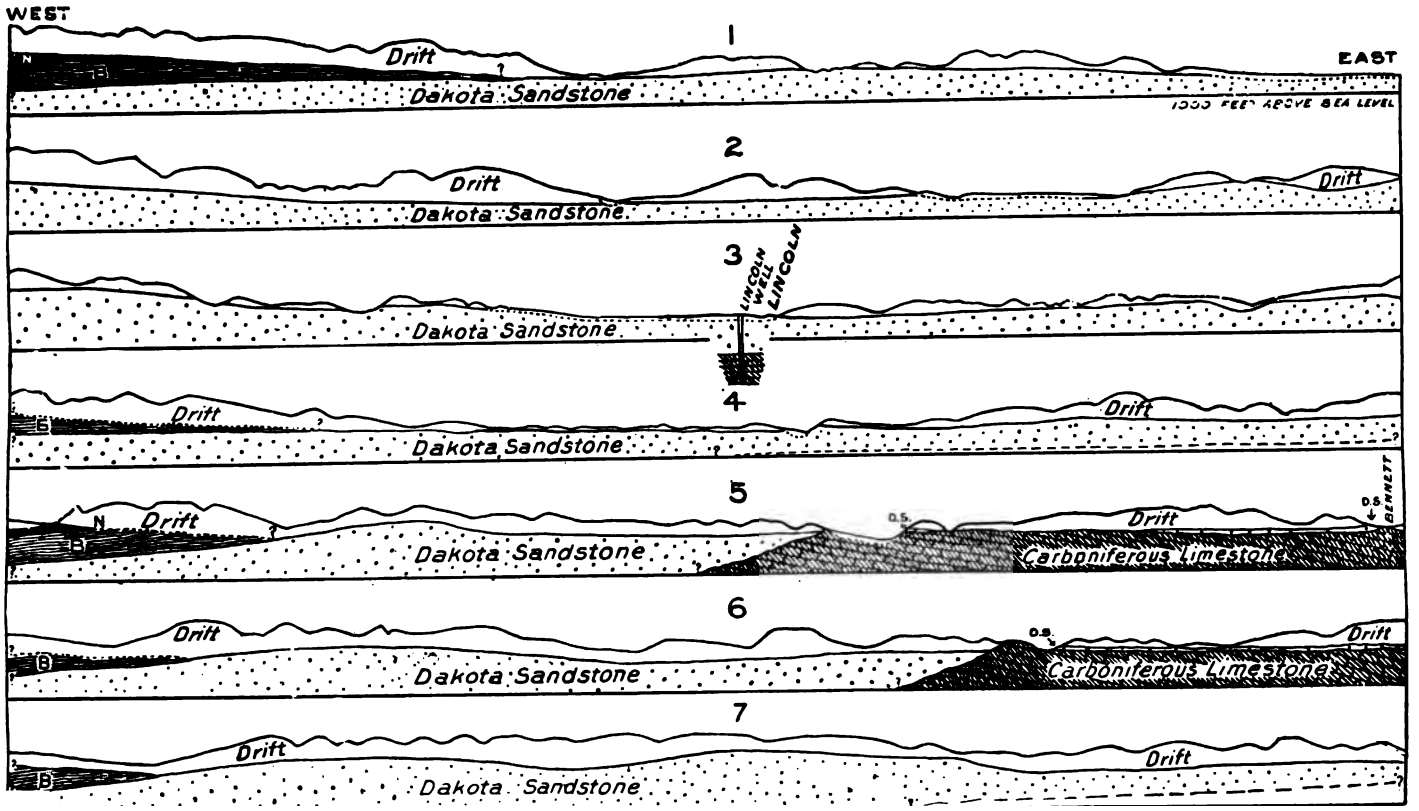


FIG. 12.—Profile of line of wells along Central avenue, Kearney, Nebraska.

GAGE WELLS AT KEARNEY.

A series of wells were sunk under the direction of Prof. O. V. P. Stout during the spring of 1896. These were located in a nearly north-south line, at distances of about one-half mile from each other. The first, or No. 1, is in the sand hills 2½ miles south of the bridge across Platte River at Kearney, on the main road. Nos. 2, 3, and 4 are successively one-half mile apart north from No. 1. No. 5 is on the south bank of the river. There is also near this a gage rod, marked in the table "S. R.," this being the southerly gage, showing the height of open water. About the middle of the bridge is a well, known as "5*a*," sunk in the low island, submerged at high water. At the north end of the bridge is the gage rod marked in the table "N. R.," about one-half mile from well No. 6, on the north side of the river. This well was tampered with and subsequently replaced, readings being begun on August 17. The remaining wells, Nos. 7, 8, 9, and 10, are


WEST
EAST
1
Drift
Dakota Sandstone
1000 FEET ABOVE SEA LEVEL
2
Drift
Drift
Dakota Sandstone
3
LINCOLN WELL LINCOLN
Dakota Sandstone
4
Drift
Drift
Dakota Sandstone
5
N
Drift
B
Dakota Sandstone
O.S.
Drift
Carboniferous Limestone
O.S. BENNETT
6
Drift
B
Dakota Sandstone
O.S.
Drift
Carboniferous Limestone
7
Drift
B
Dakota Sandstone
Drift

on Central avenue in Kearney, Nos. 9 and 10 being a short distance north of Midway Hotel. The elevations of the tops of the well casings, as determined by careful leveling, and of the zeros of the two rods, are given in the following list, referred to the Union Pacific datum:

Elevation of top of well casing; wells near Kearney.

Well.	Elevation.	Well.	Elevation.
	Feet.		*Feet.*
No. 1	2,157	No. N. R	2,137.49
No. 2	2,148.96	No. 6	2,139.50
No. 3	2,145.97	No. 7	2,142.66
No. 4	2,143.01	No. 8	2,146.31
No. 5	2,141.88	No. 9	2,149.82
No. S. R	2,137.57	No. 10	2,154.85
No. 5*a*	2,139.99		

The following table gives the reading of distance of the water surface below the top of the well casing:

Distance of water surface below top of well casing; wells near Kearney.

Date.	Day.	1.	2.	3.	4.	5.	S. R.	5*a*.	N. R.	6.	7.	8.	9.	10.
April	19	.....	9.90	7.00	3.30	2.90	.....	.....	.....	1.30	6.70	11.50	17.70	23.10
	26	.....	9.50	6.40	3.80	3.00	.....	.....	.....	.....	6.20	11.00	17.10	22.70
May	3	.....	9.10	6.10	3.10	2.90	.....	.....	.....	.....	6.50	11.40	17.60	23.10
	10	.....	9.40	6.85	3.40	3.00	.....	.....	.....	.....	6.20	11.15	17.35	22.90
	18	.....	9.26	6.45	3.10	2.85	.....	.....	.....	.....	6.55	11.80	17.10	23.50
	25	16.50	9.45	6.62	3.38	3.05	.....	.....	.....	.....	6.80	11.37	17.36	23.65
June	1	16.04	9.05	6.55	2.93	2.82	.....	.....	.....	.....	5.90	10.92	16.95	23.15
	8	16.25	9.28	6.62	3.10	3.02	.....	.....	.....	.....	6.01	11.10	17.10	23.28
	18	16.50	9.56	6.83	3.35	3.40	.....	.....	.....	.....	5.81	10.75	16.98	22.95
	23	16.55	9.60	6.90	3.45	3.50	.....	.....	.....	.....	5.89	10.80	17.10	23.20
	30	16.43	9.61	6.70	3.15	3.12	.....	.....	.....	.....	5.68	10.61	16.76	22.65
July	9	16.40	9.38	6.61	3.18	3.15	.....	.....	.....	.....	5.59	10.35	16.68	22.83
	16	16.80	9.85	7.10	3.61	3.72	.....	.....	.....	.....	6.01	10.98	17.30	23.31
Aug	12	15.39	8.65	6.36	4.09	2.76	1.11	.....	1.20	.....	6.08	10.56	16.05	22.06
	17	15.50	8.78	6.42	4.00	2.81	0.98	1.94	1.26	1.94	6.25	10.59	16.05	22.14
	22	15.43	8.75	5.81	4.02	2.92	0.89	1.70	1.09	2.15	6.11	10.94	16.08	22.13
	29	15.69	8.84	6.53	4.16	3.95	—0.52	2.49	—0.43	2.61	6.25	10.63	16.16	22.15
Sept	5	15.71	8.85	6.56	4.20	3.87	—0.17	2.52	—0.23	2.69	6.30	10.67	16.13	22.12
	12	15.75	8.89	6.60	4.24	3.96	0.84	1.57	—0.07	2.68	6.41	10.73	16.15	22.14
	19	15.80	8.94	6.65	4.18	2.75	1.07	1.39	1.23	1.95	6.27	10.76	16.21	22.22
	28	15.84	8.97	6.68	4.07	2.81	1.03	1.35	1.18	1.96	6.16	10.80	16.25	22.25
Oct	4	15.88	9.01	6.72	4.05	2.84	0.95	1.40	1.16	1.99	6.12	10.75	16.25	22.25
	11	15.91	9.05	6.76	4.05	2.81	1.01	1.49	0.79	2.13	6.15	10.79	16.29	22.29
	18	15.92	9.06	6.77	3.97	2.78	1.03	1.42	1.06	1.89	6.04	.....	16.30	22.30
	26	15.95	9.11	6.70	3.94	2.80	1.03	1.42	0.98	1.75	6.06	.....	16.33	22.33
	31	15.97	9.13	6.79	3.90	2.65	1.15	1.10	1.34	1.39	6.06	.....	16.30	22.30
Nov	8	16.00	9.18	6.74	3.82	2.54	1.82	.....	1.94	1.28	6.08	.....	16.36	22.32
	15	16.02	9.20	6.69	3.76	2.71	1.13	1.25	1.38	1.95	6.11	.....	16.38	22.36
	21	16.05	9.22	6.73	3.76	2.55	.....	.....	.....	2.04	6.08	10.85	16.41	22.39
	30	16.08	9.24	6.76	3.72	2.39	1.39	Frozen	1.58	1.82	6.13	10.76	16.45	22.47
Dec	7	16.11	9.27	6.65	3.65	2.50	1.35	.....	0.86	1.87	6.15	10.98	16.40	22.40
	13	16.13	9.29	6.57	3.59	2.52	1.29	0.98	1.45	1.55	6.06	10.80	16.42	22.39
	19	16.16	9.33	6.52	3.54	2.46	1.52	Frozen	1.51	1.75	6.00	10.82	16.45	22.40
	29	16.14	9.25	6.54	3.55	2.45	1.36	Frozen	1.53	2.00	5.98	10.77	16.41	22.43

KEARNEY COUNTY.

Kearney County extends from Platte River far southward across the divide between the Platte and Republican rivers. The greater part of its area is high, level plains, terminated northward by the Platte Valley along a zone bordered by sand hills. Little Blue River heads in the eastern part of the county and has cut a moderately deep valley north of Norman. The underground waters lie in a sheet of gravels and sand which slopes gently to the east and southeast. Under the higher land in the central and southwestern portion of the county they lie from 100 to 155 feet below ground. To the north and east the depth diminishes gradually, and in the lower lands along Platte Valley they are only a few feet below ground. At Minden the water level is 80 feet below ground, but ordinarily wells are sunk 40 or 50 feet into the water-bearing beds.

As the land rises to the southeast the underground waters lie deeper, but as the water-bearing horizon also rises gradually to the west the increase in depth does not correspond precisely with the increased altitude of the land. At Keene the water level is about 105 feet below ground, and wells are sunk to a depth of 120 to 160 feet. North of Wilcox the water level varies from 110 to 135 feet in a rather irregular manner; and to the south, as the land rises rapidly in the southwestern corner of the county, the water level is found to be considerably over 150 feet below ground. At Axtel the water level closely approximates 100 feet below ground, being a little less to the north and a little more to the south. At Norman the town wells have a depth of 100 to 125 feet, with the water level at about 95 feet below ground. About Hartwell the water level is about 65 feet deep, but is somewhat deeper than this in the village. Along the belt of sand hills the waters are obtained at various depths, but often fair supplies are yielded by moderately shallow wells. On the lower lands in the Platte Valley the waters are rarely over 45 feet below ground, the depth gradually decreasing toward the river. About Lowell the water surface is from 6 to 9 feet below ground; at Newark it averages about 8 feet, but wells ordinarily are sunk 8 or 10 feet into the water-bearing beds.

PHELPS COUNTY.

The configuration and relations in Phelps County are similar to those of Kearney County, but the flat-topped divide between the Platte and Republican valleys is a somewhat more elevated ridge. Along the southern margin of the county the land slopes toward Republican River, and in the southwestern corner of the county, which was not investigated as to its water resources, there are deep canyons which contain head waters of small lateral branches of

Republican River. The underground waters lie in a sheet of gravel and sand, which dips southeastward, but presents some local variations in the regularity of its inclination. The dip of the beds to the southeast is slightly less than the upward slope of the land southwestward, so that to the north and east the waters lie at a less depth than they do farther west. In the highest area of the plains, southwest of Holdrege, the water level lies over 200 feet below ground. The depth decreases regularly northeastward to the edge of the plains south of the valley of Platte River. In the valley of Platte River there is a narrow strip of land along the river in which the water level is less than 10 feet below ground, but southward, through the belt of sand hills to the edge of the valley, the waters lie mainly within 25 feet of the surface of the ground.

At Holdrege the city wells have a depth of 200 feet and contain 60 feet of water. The water level in the vicinity is very uniformly at 140 to 160 feet below ground. At Atlanta it is 180 feet below ground; about Sacramento it varies from 120 to 140 feet; at Funk it is 125 feet; at Axtel, 100 feet; and at Loomis, 180 to 190 feet.

DAWSON COUNTY.

The underground waters of Dawson County present a wide range of variation in their depths, from very near the surface in the immediate vicinity of Platte River to over 300 feet in the high lands in the northwestern portion of the county.

The water level corresponds quite closely in altitude with the bed of Platte River and has a similar gentle inclination to the east and southeast. The exceptional depth of the waters in the northern portion of the county is therefore mainly due to the altitude of the land above the river, but it is in some measure increased by a diminished quantity of water in the upper beds of the water-bearing series. The zone in which the water surface is less than 10 feet below ground is narrow along the south side of Platte River, but extends to and beyond the Union Pacific Railroad at some points east of Lexington, and it is unusually wide in the vicinity of Cozad. In Cozad an excellent supply of water is obtainable at depths of 6 to 8 feet below ground in wells from 20 to 30 feet deep. About Lexington the water surface is from 21 to 22 feet below ground, and wells average from 25 to 35 feet in depth. Similar conditions prevail over a wide belt extending northward to the base of the slopes which rise to the table-land lying between the valleys of Platte and the South Fork of Loup rivers, the depths gradually increasing as the land gains in latitude.

North from Cozad, where the bottom of the valley has a relatively rapid rise, there is a considerable area within the valley where the water surface is over 50 feet below ground and wells are between 100 and 120 feet deep. In the high ground lying between the valleys

of Platte and Wood rivers, and again on the north side of the valley of Wood River, the waters lie at a depth below ground in proportion to the increasing height of the land. Eastward in this region there are wells which obtain water supplies within 200 feet of the surface of the ground, but westward the water surface rises less rapidly than the land surface, and it is necessary to go considerably deeper for water supplies. In this portion of the county the greater number of wells are sunk in depressions, to avoid the necessity for sinking them to the depth necessary on the higher ridges. Wells on the higher lands are over 300 feet deep.

In the valley of Wood River the water surface lies from 25 to 35 feet below ground in greater part, and yields satisfactory supplies to many wells of moderate depth. At Sumner the principal supplies are obtained from wells 93 feet deep, in which the water surface is 25 feet below ground.

In the south-central portion of Dawson County there are abundant water supplies at moderate depth in the valley of Platte River, obtained in wells from 25 to 30 feet deep near the river and from 35 to 45 feet deep back toward the foot of the upland. Southward, on the top of the table-land, the water surface lies from 220 to 250 feet below ground in greater part, but there are a few local exceptions. The wells are mainly tubular and have depths of 222 to 285 feet.

NORTHERN GOSPER COUNTY.

The greater part of this region is an elevated plain, invaded from the south by many canyons at the heads of branches of the Republican River, and traversed northward by the wide, deep valley of Plum Creek. Its northeastern corner extends to Platte River and covers a small area along the south side of the valley of Platte River. The underground waters lie at approximately the same altitude as the bed of Platte River, with a gentle general slope to the east and southeast. The waters are in a great sheet which is probably flowing very slowly to the east, and in some measure to the south into the deep valley of Republican River. The depth to the water surface is closely related to the altitude of the land above Platte River.

Along the central area of plains constituting the divide between Plum Creek and waters draining into the Republican River the water surface lies from 180 to 280 feet below ground, the increase being quite regular to the west. About Smithfield wells have a depth of 240 feet and contain 18 feet of water; at Elwood the depth is 320 feet and the wells contain 20 feet of water. On the high lands between Plum Creek and the Platte Valley the water surface lies 150 feet below ground north of Smithfield, and between 200 and 220 feet north of Elwood and in the extreme northwestern corner of the county. Along Plum Creek, waters are usually obtained within 150 feet of the surface in the western part of the county, and within 50 feet of the surface in

the eastern part of the county, the rate of decrease being fairly regular as the valley is descended. In the valley of Platte River, in the northeastern corner of the county, the water surface lies within 6 feet of the ground surface immediately adjoining the river, and within from 20 to 30 feet toward the foot of the highlands.

PROSPECTS FOR DEEPER-SEATED WATERS.

Although a number of deep borings have been made in the central and western portions of the area to which this report pertains, they appear not to have gone to a depth sufficient to reach the formations in which water supplies might be expected. A boring at Kearney attained a depth stated to be 2,460 feet, where it was discontinued, far down in the Pierre shale. One at Hastings reached a depth of 1,145 feet; one at Dannebrog a depth of 1,000 feet; one at York, 590 feet; and one at Seward was bored to a depth of 610 feet. At the latter place the Dakota sandstone appears to have been penetrated, but it did not yield a flow. In the other borings this formation was not reached.

In South Dakota the Dakota sandstone carries a very large volume of excellent water under high pressure which is available over a wide area in the eastern part of the State and in the depressions of the Missouri and confluent valleys. This water passes into the formations along the foothills of the Black Hills and the Rocky Mountains at altitudes of from 3,000 to 5,000 feet, and has a great pressure and high head in the eastern part of South Dakota. This pressure and head diminishes gradually toward the southeast, and finally in the extreme corner of the State flowing water can not be obtained. This is due to the fact that the formation reaches the surface along Big Sioux River and the Missouri River below Vermilion, so that the waters are free to escape and thus lose their volume and pressure. Precisely the same conditions are found in the northeastern corner of Nebraska, and it is reasonable to believe that they may be found to be essentially the same over a wide area in central Nebraska, especially on the lower plains and along such valleys as the Platte, where the land is not elevated much higher than in the eastern part of South Dakota.

The Dakota sandstones outcrop in Lancaster and adjoining counties, where they are free to lose their water, and this is also the case with the upper members of the Carboniferous formations which outcrop extensively in the counties east and southeast of Lancaster. In this area the Dakota sandstone is seen to be full of water in hundreds of wells which have been sunk in it, and from its outcrops flow innumerable springs, which do much toward filling the small streams of Lancaster County. These waters are in all probability largely derived from an intake zone along the western outcrops, and it is believed that much of the water passes under the entire length of the State of Nebraska, as shown in Pl. IV, to the wells and springs which

extend along a zone of outcrop of Dakota sandstone in Lancaster, Gage, Saunders, Dodge, Burt, Thurston, and Dakota counties. A typical spring in this belt is shown in Pl. XIX. Of course these waters have but very slight head in Lancaster County, but they nearly all rise at least a few feet in the wells which are sunk to them. Westward, however, away from the zone of leakage, we should expect the pressure to gradually increase, as it does to the north and west in South Dakota. Whether the increase would be at a sufficiently rapid rate to give flows at the surface in the central and western portion of the area to which this report relates can not be predicted from our present means of calculation.

In the following diagram I have introduced a sketch of a piece of physical apparatus which illustrates the increase of head away from the leak toward the source of pressure, representing closely the relations which appear in the South Dakota artesian basin, and probably in a measure also those of central and eastern Nebraska. It will be seen that the gradient is a relatively rapid one, but we must bear in

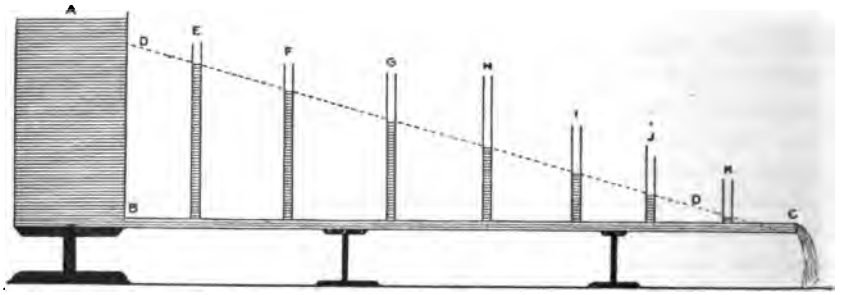


FIG. 13.—Diagram of apparatus for illustrating the declivity of head of liquids flowing from a reservoir.

mind that the distance from eastern Nebraska to the Rocky Mountains is very great and much of the intervening land slopes up to a fairly high altitude. There is another condition which may be adverse. The Dakota sandstone is exceedingly variable in physical character. In Lancaster County and in the belt extending northward to the Missouri River at Dakota City the sandstone is porous, clay is not predominant, and the conditions are favorable for the transmission of large water supplies. It may be that westward the formation becomes finer grained over a greater or less area in such manner as to choke out water. Of this, however, there is no definite evidence. In the outcrops in Jefferson County there is considerable clay admixture, but many of the beds are sufficiently porous to carry the water. The outcrops are found far westward in Kansas, not far south of the Nebraska boundary, and they appear to be coarse and suitable for bearing water.

In the next underlying formation, the Carboniferous limestones, flowing water has been obtained in considerable volume in the wells at

Lincoln, but it is so salty that the wells are more likely to prove useful as sources of salt supply than for anything else. It is probable, however, that this saline water is of relatively local occurrence, occupying a basin under eastern Nebraska, and that farther westward the waters in the Carboniferous formation may be perfectly fresh, or at least only slightly mineralized. It would hardly be safe to offer this as a prediction, but it is worth bearing in mind as as a possibility. At Omaha, northward in Dakota, and eastward in Iowa excellent waters are obtained from Carboniferous limestone. It is therefore desirable to point out the advisability of sinking deep wells in the region west of Seward and Saline counties to test, in the first place, the water resources of the Dakota sandstone, and if these are inadequate, to drill deeper to the underlying formations. The depth to which it would be necessary to go can not be definitely calculated from data now on hand. At Kearney the Pierre shales were reported to extend from a depth of 71 feet to 2,460 feet, the bottom of the boring; but it is believed that the top of the Dakota formation was not far below. Eastward the thickness of Cretaceous shales diminishes gradually as the Dakota and underlying formations rise toward the surface and the land decreases in altitude. Some of these relations are further illustrated in Pl. IV.

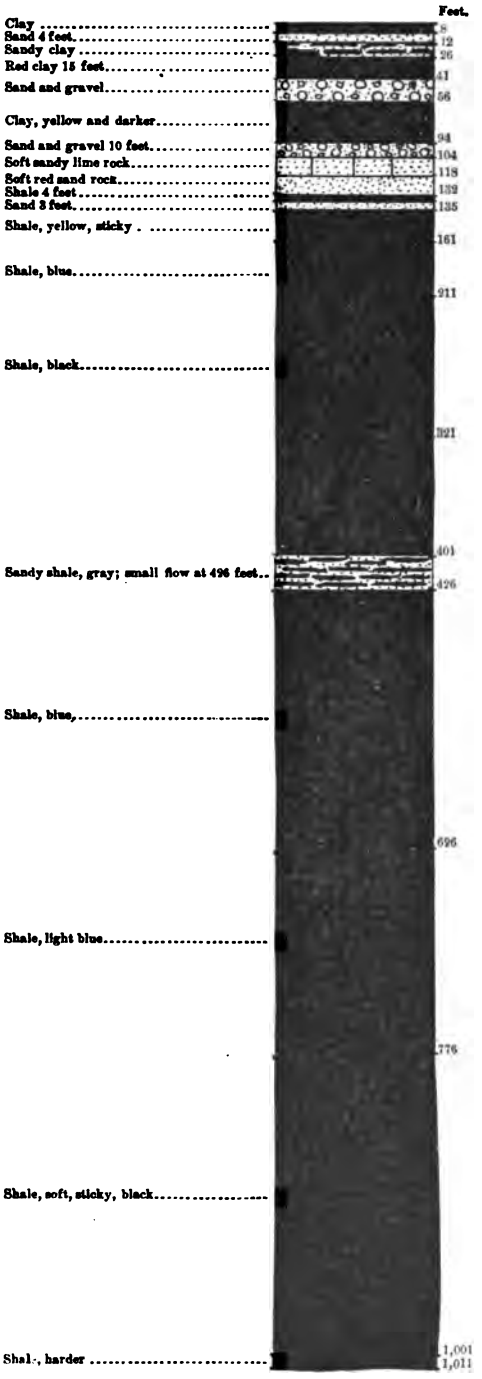


FIG. 14.—Record of deep boring at Dannebrog, Howard County, Nebraska.

Owing to the difficulty of sinking a boring in the overlying clays of the Cretaceous formations, expert well drilling will be necessary, and borings should be very large at the top. The experiments will be expensive, but it is hoped that at some such point as Grand Island, Hastings, Kearney, or North Platte an attempt will eventually be made to ascertain the resources of the Dakota sandstone and, if necessary, the underlying formations.

IRRIGATION BY UNDERGROUND WATERS.

At many points in this region the underground waters have been employed for irrigation. In the Beaver Crossing area the artesian flows have been used, but elsewhere the supply has to be lifted to the surface with windmills. In greater part the irrigated areas have been only a very few acres or a garden. Under most of the region there are ample supplies of water for extensive irrigation, but with windmill pumping it usually has not been found practicable to irrigate properly over 10 to 15 acres from one mill. When the waters lie over 75 or 100 feet below ground the amount available is less, for the efficiency of pumping rapidly decreases beyond a moderate depth. Very few irrigators regard artificial watering as profitable for large field crops of low market value, but for small, diversified crops for family subsistence and local sale, and some special crops, such as potatoes, pump irrigation is certain to be appreciated as a necessity in dry seasons and a useful adjunct even in the more rainy ones.

In traveling over the area to which this report relates an endeavor was made to obtain some data in regard to the methods and results of farm well irrigation in the various counties. Information was also gathered in regard to irrigation in the Beaver Crossing artesian basin. The results of these inquiries are set forth in the following pages.

LANCASTER COUNTY.

In this county there is considerable irrigation in a small way, mainly of garden areas. Some experiences of irrigators are as follows:

Mr. H. G. Weber, gardener, west of Lincoln, irrigates garden truck, including onions, radishes, lettuce, spinach, asparagus, pieplant, eggplant, pepper, cabbage, tomatoes, cucumbers, celery, and other vegetables. His well is 60 feet deep, but the water rises to within 26 feet of the surface. The pump has a 3-by-10 cylinder. The reservoir is on the highest land and has a capacity of 1,000 barrels. In a good wind the pump supplies 10 to 12 barrels per hour. Mr. Weber states that, although his plant is small, the results have been very satisfactory.

Mr. E. H. Cushman, near Lincoln, states that he has been irrigating a market garden for two years. He has a 12-foot aermotor windmill, which runs a pump with 6-inch cylinder and a 12-inch stroke, raising about 2 gallons of water to the stroke. The well is about 32 feet deep, with approximately 14 feet of water, in large supply. The reser-

voir is 50 by 100 feet and 4 feet deep. Can irrigate 10 acres. Has also built a "Jumbo" mill to run two pumps with 3-inch cylinders, 12-inch stroke.

Mr. E. E. Smith, near Lincoln, irrigates 5 acres, mainly of garden truck. He has a well 25 feet deep, containing 12 feet of water. His reservoir is 50 feet square. Water is pumped with a 5-foot aermotor.

SEWARD COUNTY.

In the artesian area along Blue River, in the vicinity of Beaver Crossing, the waters have been used by a number of farmers for irrigation of small areas. The results have been very satisfactory, and the disposition to introduce irrigation in this area is growing in a most encouraging manner. Only a few facts have been obtained in regard to irrigation plants and results.

Mr. J. T. Godding has a well which is 105 feet deep, 3 inches in diameter, and yields 125 gallons per minute, which will rise to 25 feet above the surface. He irrigates, with good results, a field 40 rods square, which is flooded directly from the wells.

M. M. Martson, near Beaver Crossing, irrigates 10 acres with artesian waters in dry seasons. He has a 3-inch well, 100 feet deep, and the water rises 20 feet above ground. The reservoir is 2 rods wide by 40 rods long and 8 feet deep.

Messrs. Horney and Evans have two flowing wells, with water at depths of 90 to 100 feet, which rises 15 feet above ground. They are 3 inches in diameter and flow 100 gallons each per minute. In dry seasons they irrigate potatoes.

Mr. Thomas Wilson, near Beaver Crossing, has a 4-inch flowing well, 125 feet deep. The water rises 5 feet above ground. His reservoir is 40 by 60 feet. Three acres of potatoes irrigated in 1896 yielded twice the product obtained from adjoining fields not irrigated.

Mr. Thomas Trilzman, near Beaver Crossing, irrigates from a flowing well. His reservoir is 100 by 50 feet and 6 feet deep. His corn yielded 85 bushels and prairie grass 2 tons per acre. Sugar beets were found to be greatly benefited by the water.

Mr. F. M. Dimery, near Beaver Crossing, has nine flowing wells on his farm, of which the average depth is 100 feet. Four of them are 3-inch pipe, and flow about 150 gallons per minute. Two of the wells have been used for irrigating 60 acres of land direct from the wells in small ditches made with a plow. Mr. Dimery has also irrigated a 2-acre garden and 6 acres of meadow.

On the Fountain Head Experimental Farm, near Beaver Crossing, Mr. T. C. Ferguson has irrigated extensively by artesian waters.

Mr. J. W. Arasmith has wells near Beaver Crossing, and a half-acre reservoir with 4-foot banks, but has not as yet irrigated.

Mr. M. Powell irrigates a small area of bottom land from his flowing well.

FILLMORE COUNTY.

Mr. J. H. Little, near Fairmont, has irrigated to some extent. He has two bored wells, 70 feet deep. His pumps are 8½ by 16 inch cylinders, and 1½-inch pipe is used. A 12-foot windmill works both pumps, yielding from 10 to 20 barrels per hour. He irrigates 5 acres of orchard in the autumn and winter, and estimates that the yield was about doubled by irrigation. His reservoir is 30 by 150 feet.

YORK COUNTY.

Mr. L. D. Stilson, near York, is irrigating from two small ponds. One is 25 by 40 feet, carrying 30 inches of water, supplied from the overflow of house well, 40 feet deep, pumped by windmill. The overflow is used for lawn and shrubbery. The other pond is 40 by 100 feet and contains 4 feet of water, supplied by a 4-inch pump with windmill from a well 40 feet deep. During January and February he pumped water directly onto a little more than an acre of strawberries, with very satisfactory results. He is planning to put in a third pond, 75 by 200 feet, pumping the water 75 feet, to supply apple, peach, and cherry orchards.

Mr. F. E. Porter, at McCool Junction, has irrigated from a pond 70 feet in diameter, 5 feet deep, and capacity of 4,000 barrels. He employs a 12-foot Eclipse mill, with 5-inch cylinder, which pumps 1,000 barrels in twenty-four hours, in a good, steady wind. He employs hose of 10-ounce oiled ducking for distribution of water. His results in irrigation of garden truck have been most satisfactory. Many other persons irrigate small truck patches with ordinary windmill pump.

HAMILTON COUNTY.

Mr. G. L. Cushman, near Chapman, is irrigating with considerable success. He employs a Dempster vaneless 16-foot mill, with 8-inch cylinder and pipe. It is 32 feet from surface to bottom of screen, and the water level can not be pumped down. The reservoir is 110 feet in diameter, and is located on a portion of the land which is slightly higher than the adjacent fields. His ditches are dug, with banks of the excavated material. Potatoes have been the crop, but the plant as it now stands will hardly supply water enough for 5 acres in dry seasons. Irrigation was found to increase the crop to a very notable degree, but no precise figures are offered.

BUFFALO COUNTY.

Mr. Joseph Buck, near Shelton, irrigated about 1 acre of potatoes in 1895. His well is 25 feet deep, and with his present pumping arrangements yields about 150 gallons per minute in a fair wind. The supply appears to be inexhaustible. His reservoir is one-half acre in size.

Mr. W. K. Wright, near Gibbon, irrigates from a reservoir 1 acre in area, with banks about 5 feet high on the outside. The water supply is from two 12-inch pumps operated by two 16-foot windmills, each pump delivering about 130 gallons per minute in a fair wind. The water level is 10½ feet below the surface. One of the pumps draws the water from eight 3-inch pipes radiating from a chamber which fastens to the bottom of the cylinder. Each of the radiating pipes is 4 feet long, the outer ends connecting with elbows to perpendicular pipes with gauze points driven 12 feet into the water. The other pump is supplied from an open well 54 feet deep, 16 inches in diameter, with 700 three-quarter inch auger holes, covered with gauze, near the bottom. The largest volume of water is in gravel 18 feet thick, beginning 10½ feet below the surface. Below this the water contained too much quicksand. Mr. Wright has found that flooding the land in the autumn and winter is very beneficial to the crops of the ensuing season. In 1895, 20 acres of corn were irrigated once, at earing time, with the gratifying result of doubling the crop over that of adjoining nonirrigated lands. He has raised 150 bushels of potatoes per acre. His main ditches are 2½ to 4 feet wide, according to the slope of the ground. The land does not carry water well for long distances. He thinks he can depend on irrigating 25 acres, with water to spare some seasons for the further irrigation of from 15 to 20 acres more.

Mr. R. M. Jones, near Elm Creek, irrigates with a Dempster mill, 16-foot wheel, pumping from eight 3-inch points driven from the bottom of a hole 8 feet deep, 11 feet in diameter, into water-bearing gravels below. He has been able to wet about 25 to 30 acres by running the water out over the frozen ground. Corn, wheat, barley, and oats yielded very fine crops, which, however, were seriously damaged by hail before harvesting.

DAWSON COUNTY.

Along the valley of the Platte in this county irrigation from shallow wells by windmills has been practiced at several localities. Information could be procured from only a few of the irrigators. The following statements are representative:

Mr. G. Malchow, near Lexington, irrigates from a 20-foot well with pumping outfit and reservoir situated on a low knoll, which is about 8 feet higher than adjoining portions of the farm. The pump consists of an 8-inch pipe, 20 feet long, with two laterals, 2 inches in diameter, driven down 19 feet deep into the water-bearing beds. The first water is 21 feet from the top of the knoll, in a bed of gravel 2 feet thick, underlain by 10 to 12 inches of clay and sand, below which are other water-bearing gravels. The reservoir is 6 feet deep, 150 feet long, and 100 feet wide. In 1895 the wind had sufficient force to keep this reservoir about full from March to the 1st of July. Two acres were planted in potatoes and 1 acre in a variety of garden truck,

including lettuce, onions, beets, carrots, cabbage, etc. The water was turned into these fields about twice a week, and the products were large and fine. Owing to lack of market, however, the operation was not a profitable one. In the middle of June, Mr. Malchow irrigated 2 acres of potatoes, and these yielded, on harvesting, about 100 bushels to the acre. Potatoes in the adjoining fields not irrigated made practically no crop at all. There were also irrigated 2 acres of oats, which made 40 bushels to the acre, while other oats in the vicinity made only 10 bushels. By comparing results with neighbors who apply the water direct from the wells, it was found that storage in reservoirs is very necessary, both to gain sufficient volume for irrigation and to allow the water to acquire the proper temperature.

Mr. G. Ballmer, near Gothenburg, has a Dempster irrigation outfit, consisting of 8-inch pump, 30-foot tower, and 16-foot open wheel. The well is 40 feet deep, 8 feet wide, and has six 2-inch pipes 29 feet long, with sand points which are driven down into the gravel. They connect in the bottom of the well with an 8-inch cylinder. He estimates that by running the pump continuously he could irrigate 20 to 30 acres. His reservoir is 60 by 200 feet, with banks about 4 feet high. At present he is irrigating only in a small way—fruit trees, truck patch, a few acres of potatoes, and 5 acres of corn.

Mr. Alex. I. Johnson, near Lexington, makes the following statement: He has an 8-inch pump with six 2-inch pipes attached. The water level is 14 feet below the surface and the supply is very large. With a 10-inch stroke his mill pumps about 100 gallons per minute. The reservoir is 100 feet long by 60 wide, and holds water sufficient for about 2 acres at a time. From this plant he has irrigated from 10 to 12 acres, which have yielded good crops during seasons when the crops failed completely on nonirrigated land. His potatoes have yielded 110 bushels, corn 40 bushels, while in nonirrigated areas only 15 bushels were obtained last season.

Mr. L. A. Lewis, near Cozad, gives the following particulars in regard to his irrigation operations: His well is 20 feet by 8 feet, with six sand points driven 10 feet below and connected with an 8-inch cylinder. The water level is 22 feet below the surface. His windmill is 16 feet in diameter and has a 10-inch stroke. He believes that with a sufficiently large reservoir, in a moderately windy season, he could irrigate from 50 to 60 acres. He has not, however, built a reservoir. During the last two seasons he has raised potatoes, onions, and other vegetables. In the season of 1896 he raised 250 bushels of onions on 30 square rods. His potatoes yielded 250 bushels per acre in 1895. On adjoining fields not irrigated the potato crop was practically nothing. He realizes the necessity of having a reservoir to furnish the water in sufficient volume and at the proper temperature.

Mr. Oliver Miller, near Cozad, has a plant to irrigate about 5 acres in the Platte Valley. His well is 45 feet deep and contains the usual

large water supply. His windmill raises about 25 gallons per minute under a favorable wind. The reservoir is 5 rods square and holds 4 feet of water. His crops have been potatoes and garden truck, of which the yield is about doubled by irrigation.

Mr. A. F. Velt, near Lexington, irrigates from 10 to 15 acres in dry seasons. His well is 62 feet deep and the windmill a 16-foot Dempster. The reservoir, 60 by 100 feet in area and 4 feet deep, can be filled in about four days with a 6-inch stroke. Mr. Velt reports very satisfactory results with potatoes, onions, cabbage, corn, and miscellaneous garden truck.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 13

IRRIGATION SYSTEMS IN TEXAS.—HUTSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 13

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

IRRIGATION SYSTEMS IN TEXAS

BY

WILLIAM FERGUSON HUTSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

CONTENTS.

	Page.
Letter of transmittal	7
Introduction, by F. H. Newell	9
General statement	17
Retardation of development	18
Use of water	20
Distribution of rainfall	21
Climatic and geographic divisions	24
Description of irrigation works and projects	25
Eastern Gulf coast region	25
Central Texas	28
San Antonio and vicinity	41
Nueces River and Lower Rio Grande	50
Llano Estacado	59
Pecos Valley	62
Trans-Pecos Texas	65
Index	67

ILLUSTRATIONS.

		Page.
PLATE I.	View of run-off of San Marcos spring	9
II.	View of portion of water wheel, showing buckets raising water	38
III.	View of Austin dam and power house	40
IV.	View of San Antonio River at Mill bridge	42
V.	View of old stone aqueduct carrying Espada ditch across Piedras Creek	44
VI.	View of artesian wells at San Antonio city waterworks	46
VII.	*A.* View of dam supplying Madre ditch at Del Rio	56
	B. View of dam for San Felipe ditch at Del Rio	56
VIII.	View of flume across Pecos River	62
IX.	View of Pecos Canyon at Southern Pacific Railway bridge	64
X.	View of wing dam of El Paso Irrigation Company, looking upstream	66
FIG. 1.	Index map of Texas	22
2.	Diagrams of mean monthly rainfall at six stations	23
3.	Map of drainage basin of Wichita River	30
4.	Water wheel and wing dam turning current against wheel	38
5.	Map of ditches and artesian wells at San Antonio	42
6.	Mission ditches below San Antonio	44
7.	View of flume on Trueheart ditch	47
8.	View of irrigation tank at Beeville experiment station	49
9.	Map of the proposed Caimanche reservoir and canals	52
10.	Map of the proposed Nueces reservoir and canal	53
11.	Pump and flume on Nueces River	55
12.	Map showing location of Margueretta Canal	62

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, November 26, 1897.

SIR: I have the honor to transmit herewith a paper entitled Irrigation Systems in Texas, by William Ferguson Hutson, and to recommend that it be published in the series of pamphlets on Water-Supply and Irrigation. This manuscript was prepared in accordance with a request made to Prof. J. H. Connell, director of the Texas Agricultural Experiment Station. Professor Connell found that it was impossible for him to give the necessary time to field investigation and the preparation of a report of results, and therefore recommended that the work be intrusted to Mr. Hutson. The field work was carried on during May and June of 1897; the paper was written during July and transmitted early in August. The data were necessarily accumulated in a relatively short time, and the author considers the paper somewhat in the light of a preliminary report. A number of illustrations used in this paper have been obtained through the courtesy of Mr. Robert T. Hill, geologist of this Survey, from his paper in Part II of the Eighteenth Annual Report.

In the preparation of this manuscript for publication considerable liberty has been taken with the arrangement and the manner of presentation. While the statements of fact have been preserved, such changes have been made in the character of the paper as seemed necessary to bring it into harmony with the series as a whole. In particular a somewhat arbitrary geographic arrangement has been adopted in place of one based on considerations of quantity of rainfall, as it appeared undesirable to make the assumption that irrigation is governed by questions of mean annual precipitation.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RUN-OFF OF SAN MARCOS SPRING.

INTRODUCTION.

By F. H. NEWELL.

In the report upon Agriculture by Irrigation, prepared for the Eleventh Census, 1890, all the facts obtainable at that time concerning irrigation in Texas were presented and discussed. It was found by the enumeration that there were in the whole State 623 persons irrigating farms, having an aggregate area of 18,241 acres, or an average of 29 acres irrigated by each person. This did not include the smaller kitchen and flower gardens, of which there were probably hundreds, or even thousands, watered by means of city supply or windmills. The definition of "a farm," adopted for the purpose of the census, included "all staple nurseries, orchards, and market gardens owned by separate parties which were cultivated for pecuniary profit and which employed as much as the labor of one able-bodied workman during the year." The land which was irrigated formed on an average only 2.43 per cent of each farm, showing that irrigation where used was practiced on only an inconsiderable portion of each landowner's holding.

Since 1890 there has been considerable progress made in the development of irrigation, and interest has been stimulated by the success recently attained in various localities. This later investigation in Texas has, therefore, been made for the purpose of procuring fresh information, especially concerning the recent developments. The facts are of interest not only to the people of that State, but to a less degree to those of the whole United States, for Texas embraces such a wide range in topography and climate that success attained within its boundaries suggests the advisability of the same line of action in some other locality. On account of this great diversity of natural conditions, irrigation has been developed along many different lines. Not only is water diverted from creeks and larger rivers, but in some localities it is held by storage, in others it is pumped from ordinary wells, and in still others it is obtained from artesian wells. Where the conditions are favorable, the swiftly flowing streams are employed in pumping a portion of their own water up to the top of the adjacent banks, or the ever-present winds of the prairies are utilized by means of windmills to bring a needed supply of moisture from far underground. In short, in the broad stretch of country from the humid

lands on the east to the arid region on the west, from the semitropic glades of the south Gulf coast to the high plains of the interior, is to be found almost every variety of physical condition and of mechanical device for supplying needed water to the soil.

When we consider the State of Texas—in area nearly a tenth of the whole United States, and with a population less than that of the little State of Massachusetts, sparsely scattered even in the humid portion, with enormous areas of rich soil but poorly tilled—the question arises, Why should irrigation be practiced? Agriculture by this method is necessarily intensive farming—a method which should be practiced amid a dense population, and one where success is attained only by thorough tilling and careful attention to details. Why then should this be taken up in a State where fertile land is so cheap and where great areas have not been touched by the plow? The answer lies in the fact that many farmers are beginning to discover that larger profits can be made by carefully tilling a small area than by attempting to diffuse their efforts over plantations of considerable size, and that in order to produce the largest yield from a given outlay of time and labor it is necessary to insure the presence of sufficient moisture at the right time. This lesson, however, has not been universally learned. The education of the great majority of farmers or planters has been such as to make them adhere to old methods, and often it is only after object lessons have been many times repeated that they are willing to concede that their broad farming is not the most profitable.

Included within the State of Texas are lands upon which irrigation was practiced as early as, if not earlier than, in any other portion of the United States, and it would thus seem that this method of agriculture should have spread and be more generally practiced than it is. It is a fair question, Why, if irrigation is so profitable, has it not become the rule rather than the exception? The answer can probably be found in the character and training of the population and in the unfriendly attitude of the laws of the State toward the development of irrigation works. The very extent of the State—the enormous areas of land that might be had almost for the asking—has tended to make the farmer look down upon little methods and disregard the small economies and the attention to detail so essential in intensive agriculture. Thus the tendency has been to leave irrigation to the Mexican, who originally practiced it, and to regard it as something almost unworthy of the consideration of a "white man." The time has come, however, for a change in general sentiment. A more diversified farming has been introduced, together with better methods, brought in to a certain extent by immigration from other States. The rapid growth of the Territories to the northwest, which are dependent for their agriculture upon irrigation, has stimulated a desire and an endeavor to attain like results by similar means, and opportunities which before have been neglected are being seized upon.

Before any considerable development can take place in irrigation, upon either a large or a small scale, facts must be known concerning the water supply. If this is to be obtained from a river, it must be known whether the low-water flow is sufficient for the purpose and whether the floods are of such size as to sweep away structures which should be permanent. Even in the case of individuals intending to pump water from the ground, questions are first asked as to whether the ground water is sufficient in volume and whether it can be obtained at a depth near enough to the surface to be profitably raised. The answer to all questions of this kind must come primarily through a comprehension of the geology of the country. Ignorance of the volume of some of the larger streams has already resulted in serious disappointment, and probably in heavy loss, to several large enterprises, and it is probable that other works of this character will not be carried out until the investors have a better knowledge of the physical conditions, of drought, and of high water. From a knowledge of the underground conditions it is possible to foretell the depth to the water-bearing strata and the general character of these, and to base estimates upon the quantity which may be obtained by properly constructed wells. Matters of this kind must be investigated if the resources of the country are to be neither underestimated and neglected nor overstated and made the basis of loss to credulous investors.

With the measurement and study of surface streams and the accumulation of facts concerning the underground structure, with reference to the amount and quality of the water available, there are closely joined considerations of methods and cost of lifting the water up to the lands to be irrigated. No general rule can be laid down as to how much any given individual can afford to expend in obtaining a water supply for irrigation. Each case must be considered on its own merits, alike as to methods and machinery, the amount of water needed, and the character and ultimate value of the crop. As a general rule it may be said that for the field crops as ordinarily cultivated irrigation, especially by pumping, will not pay; but in diversified farming, where personal attention is given by the owner to every detail, expensive methods of storing or pumping water have in the long run been found highly profitable. In order to bring out the divergence in practice there have been assembled in the following table the more important facts obtainable concerning the cost of water by the various methods described in the following pages.

This table gives in the first column the page upon which the irrigation system is described and in the next column the name in abbreviated form. In the third column are a few words to indicate the character of the system—whether the ordinary canal or ditch diverting water from a river by means of a dam, or a mechanical device, such as a windmill or pumps driven by steam or gasoline. In the next column is given the lift in feet where water is raised by pumping,

and next to this the capacity of the pump or ditches in cubic feet per second. This column also gives the total amount delivered in acre-feet in 12.1 hours, since 1 cubic foot per second flowing for this length of time will cover 1 acre a foot in depth. To the acreage two columns are devoted—the first giving the total area irrigable, or the amount which it is estimated each system will cover; and the second, the area actually watered, this applying usually to the year 1896. Beyond this is given the total cost of the system, and, wherever practicable, the cost per acre. This latter column, in the case of the larger ditches, shows the amount asked or paid per acre for water rights. The last column gives the estimated annual cost per acre for water, figures for this being rarely obtainable.

Comparison of capacity and cost of various systems of water supply in Texas.

Page.	Name.	System.	Pump.	Lift in feet.	Capacity, second-feet.	Acreage.		Cost.		
						Irrigable.	Irrigated.	Total.	Per acre.	Annual per acre.
26	Catron	50 H. P. engine	Menge	8	11.14		500	$1,500	$3	
29	Stubenrauch	8-foot windmill.		25		15	7	300	43	
29	do	12-foot windmill. *a*				30		485	16	
31	Lytle	Dam and ditch				300		25,000		
31	Lewis	do				50	10	200	20	
31	Metcalf	do					470		7	$0.75
32	Glenn	do				350	250	3,500	14	
32	McGee	do				250	75	1,500	20	
32	Swinden	80 H. P. *b*	Centrifugal		6.84	400				
33	Baker	32 H. P. engine. *d*	Worthington.		2.72	80	75	2,000	27	*c* 6.00
33	Willis	Turbine			.11		5			
33	Alldridge	20 H. P. engine. *e*			1.00	75				
33	Lindsey	30 H. P. engine. *f*			1.87		40	2,000	50	
34	Vanderstucken	18 H. P. engine	Menge		2.60		100	1,500	15	
39	Richards	Water wheel			.20		3			
39	Garrett	do			.32		12			
43	Upper Labor	Ditch				600	100			2.00
46	Trueheart	Ditch *g*			30.00	1,500	400	18,000	15	2.50
46	Kampman	Artesian well			2.32	1,000	250	3,000		
47	Pickett	40 H. P. boiler. *h*	Blakeslee	50	1.67	400	100	2,500		*c* 4.00
48	Crandall	10 H. P. boiler. *i*	Blake	48	.20			295		
49	Simmons	2½ H. P. gasoline.			.07		10	450		
49	Experiment	5½ H. P. gasoline.		48	.05	20				
55	Grover	100 H. P. boiler *j*	Menge	48	14.00	500	70	5,000		1.00

a Combined water power and irrigation.
b With reservoir.
c Approximate.
d Operating cost, $7 a day of twelve hours.
e Can water 5 acres per day.
f Operating cost, $3 per day of eleven hours.
g Water rights held at $15.
h Costs 12½ cents per hour to operate.
i Pumps into reservoir.
j Operating expenses, $4.25 per day.

Comparison of capacity and cost of various systems of water supply in Texas—Continued.

Page.	Name.	System.	Pump.	Lift in feet.	Capacity, second-feet.	Acreage.		Cost.		
						Irrigable.	Irrigated.	Total.	Per acre.	Annual per acre.
56	Miller	40 H. P. boiler	Double	39	.29	140	70	$3,000	.....	.....
56	Del Rio	Dam and ditches.	.....	.....	.....	.....	3,600	25,000	.....	$0.50
58	Urbahn	80 H. P. boiler	Pulsometer	65	1.11	125	50	.....	.....	.....
58	Sterneberg	Windmill	.....	.....	.....	.....	3	220	.....	.....
58	Charleston	12-foot windmill. *a*	.....	30	.....	.....	5	425	.....	.....
59	Closner	25 H. P. engine.	Centrifugal	.....	10.58	.....	100	.....	.....	.....
59	Rabb	50 H. P. boiler	Menge	18	20.00	.....	200	2,000	.....	.....
59	Brulay	100 H. P. boiler.	Centrifugal	22	17.82	300	200	.....	.....	.....
59	Goodrich	14-foot windmill.	.....	10	.....	.....	18	300	.....	.....
60	Wayland	3 windmills	.....	50	.....	25	.....	505	.....	.....
60	Murray	8-foot windmill. *a*	.....	124	.....	.....	1½	223	.....	.....
63	Margueretta	Dam and ditch	.....	.....	.....	40,000	6,000	150,000	$10	1.50
64	Pecos R. I. Co	do	.....	.....	.....	20,000	600	35,000	5	.50
64	Grand Falls	do	.....	.....	.....	.....	.....	.....	15	1.25
65	El Paso	.....	.....	.....	.....	30,000	3,000	220,000	.....	2.00

a With reservoir.

In looking over this statement probably the first observation that one will make is the wide diversity of costs and results. This is partly accounted for by the fact that these figures are for the most part mere estimates and are open to the suspicion of being exaggerated to serve individual interests in one case or another. In particular the volume or capacity of the ditches is usually overstated, and concerning the pumps very little is known beyond the maker's estimates, prepared for the purposes of selling his machinery. Judging from these and similar statements, the first and annual cost of water from the large ditches is very low, being from $10 to $15 per acre for water rights and from 50 cents to $1.50 per acre for annual maintenance. The cost of water per acre by pumping is usually much more, and may range from $20 to $50 per acre, or even higher.

The small cost of water from gravity ditches in Texas, as well as in other States, is more apparent than real. As a rule the larger canal companies base their selling price for water rights upon the assumption that the work will cost a certain sum and that several thousand acres will be irrigated and subsequently sold. In this assumption the corporations have often been disappointed, the work costing far more than anticipated and the sales of water right with or without land being exceedingly slow. The promoters have appreciated the fact that these lands can not be sold unless the first and the annual cost of water is kept down to the lowest figure. The struggle to maintain

the property upon the small returns has often resulted in the system going into bankruptcy or being kept in very poor condition. Sometimes, also, the estimated supply of water has not been sufficient; and thus, from one cause or another, the landowners, although nominally paying a small price for their water rights and for the annual maintenance of these, in point of fact ultimately pay a very large price for an insufficient supply. This should be borne in mind in making comparisons between the cost of water as usually given by irrigation companies and the outlay required in the case of pumping machinery.

The expense of lifting water for irrigation must, as a rule, be far greater than that of diverting a supply by gravity, but in many places circumstances or conditions are such that the former is the only method practicable. Where considerable areas are watered and the lift is small the extra cost may be more than compensated by the convenience and the possibility of controlling the source of supply. The pumping plant as a means of insurance against drought, even in humid regions, is coming to be recognized as a good investment. If properly protected from the weather it may stand for months or years without use, ready in times of deficient rainfall for immediate service in saving a crop that otherwise would be a failure.

One of the notable features in connection with pumping is the apparently low efficiency attained when one compares the amount of water which it is claimed a pump delivers with the acreage actually cultivated. Two reasons for this are apparent: The first is that the pumps may not be run to their full capacity or the water may not be used upon as large an area of ground as possible. But the principal reason often lies in the fact that the capacity of the pump is greatly overrated, and few purchasers ever make systematic tests of the amount of water actually delivered. Many disappointments have resulted from farmers attempting to irrigate with too small a volume of water. They have assumed that the pumps were delivering a certain quantity, say 2 cubic feet per second, when in fact they were raising on the average only one-third or one-quarter of this. It is almost impossible to judge by the eye as to the amount when flowing in a pipe or trough, and they have declared that the ground was not favorable for irrigation when in reality they were trying to accomplish the impossible feat of spreading water from a stream too small to traverse the ground. The real source of trouble has not been with the soil or the method, but with the insufficient supply. This difficulty might be remedied by the construction of a small reservoir or tank, into which the pumped water could accumulate for a few hours and from which a stream of considerable volume could be drawn when an application of water to the soil was to be made. This has often been neglected, to the detriment of the owner.

The amount which can be reasonably expended per acre in procur-

ing a water supply for irrigation is, as stated above, a problem for which no general rule can be given. Much depends upon the character of the crop, and particularly upon the price for which it sells. If there is always a good market for the produce, the next consideration is the skill of the irrigator. The man who is thoroughly experienced in applying water, using only the proper amount, can often afford to pay twice as much for it as can his neighbor who uses a greater quantity and obtains a smaller yield.

The quantity of water needed varies so widely that broad assumptions must be made in order to prepare any estimate of cost. Under ordinary circumstances it may be said that an amount of water equaling 12 inches in depth is sufficient in Texas for a crop season. In other words, an acre-foot of water, or 43,560 cubic feet, will irrigate an acre. A pump delivering at the rate of a cubic foot per second, or 448 gallons per minute, will give nearly 1 acre-foot in twelve hours. Assuming that this water can be held in a reservoir and that the pump is run daily for one hundred days, it should irrigate 100 acres. The cost of water rights where the supply is assured may be taken safely at $15 per acre, or for 100 acres at $1,500. This amount under these assumptions would be a fair allowance for the cost of a pumping plant.

The annual cost of maintenance of works where the water is carefully used may range from $1.50 to $2 per acre. If the pump above mentioned furnishes through the season water at the rate of 1 acre per day, the cost of operating should not exceed this amount—$1.50 to $2. This sum is relatively small for fuel and repairs, and could not be made to include attendance, and therefore it is necessary or desirable that the pumping machinery should be nearly automatic and not require constant attention. These conditions are almost impossible of attainment. Any such statement, therefore, serves as a standard for ideal conditions rather than as an example of what may be realized.

The growth of irrigation in Texas has been retarded not so much by the character of the climate or soil, or by any natural condition, as by artificial obstacles, partly legal but consisting mainly in the lack of training of the farming population. What is needed here, as in most parts of the Great Plains region, is men who know how to irrigate—how to produce the best results under given conditions. In the arid regions, where farming without irrigation is impossible, men learn the business thoroughly; but where a small amount of success can be attained by the careless tilling of large areas the farmers are apt to go on year after year following the old ways, getting a crop when the seasons are good and trusting to chance, hoping in years of drought that the next season will be better.

By the development of small irrigation works in various parts of the State farmers are becoming accustomed to the use of water and

are appreciating the benefits to be derived from having an assured amount of water. It will be necessary, however, for these small plants to multiply many times before the construction of large works can be undertaken with fair assurance of financial success. When by the multiplication of small pumping plants in various localities a considerable body of successful irrigators has been established, it will be possible to construct great canals from the larger rivers, bringing water to thousands of acres of rich lands, and to dispose of water rights at remunerative prices. The small pumping plants may therefore be considered as the necessary forerunners of more economical and efficient systems which will render possible a dense population along the fertile valleys where now farming is precarious and often unprofitable.

IRRIGATION SYSTEMS IN TEXAS.

By WILLIAM FERGUSON HUTSON.

GENERAL STATEMENT.

During the last few years general interest has been aroused in irrigation, and its importance to many portions of Texas is being better appreciated. At this time a discussion of the development of irrigation and its present condition may afford instructive suggestions not only to citizens of the State, but to persons in other parts of the country. The variety of geologic and climatic conditions and the mixed population have given rise to many methods of practice, so that in Texas there may be found representatives of nearly every system of irrigation occurring in the United States. Every degree of excellence may be noted, from that of modern machinery for raising water down to the most primitive devices for supplying it to the field. In the arid and semiarid portions of the State the methods of the early Spanish settlers are employed. Most of the cultivation is done by Mexican laborers or tenants, who cling to the old systems. Thus on most of the ditches the distribution of the water is by the Spanish method of days and hours, each holder of a water right having the use of the ditch in his turn.

The methods of applying the water are usually copied from those of the Mexicans, which consist of flooding the crops by means of little embankments or ridges of earth from 6 inches to a foot in height, so arranged as to convert the fields into checks of a size often absurdly diminutive. This system of watering has, indeed, been very largely modified by most of the American irrigators, so as to facilitate the use of machine tools in handling the crop; but the water is still wastefully used. It is to be hoped that in the present general development of irrigation more progressive methods will be inaugurated for both the distribution and the application of the water.

The early history of irrigation in Texas is hidden in the unwritten annals of the past. Several of the valleys of the Trans-Pecos country show signs of having once supported a teeming population. The lines of their irrigation canals can yet be traced for miles, while arrowheads, stone implements for grinding corn, and other relics can be found in considerable quantities. It must, however, be left to the

archæologist to determine who these aboriginal irrigators were and the probable antiquity of their work. The Pueblo Indians say that these ditches were made by the Yuma Indians, who were driven gradually westward by the Comanches and Apaches, finally settling in their present home on the Colorado River. On the Rio Grande below El Paso are several ditches, which are probably the oldest now in use in the United States. They were built by the Pueblo Indians, who, according to their traditions, migrated to this place from New Mexico at a very early date, certainly before the advent of the Spaniards under Coronado. This explorer mentions finding well-established systems of irrigation among the Indians in this vicinity in 1540, when he passed on his expedition northward. The old Spanish mission ditches around San Antonio, mentioned on later pages, are also worthy of note as among the oldest in the United States.

RETARDATION OF DEVELOPMENT.

Taking into consideration the climatic conditions and the object lesson furnished by the old ditches, it is somewhat remarkable that irrigation has not been more generally developed in Texas. The causes for the slow growth of this method of agriculture in the State as a whole are found in the persistent attempts of the settlers to extend methods of farming applicable in the humid East, and in the existing laws modeled on those of the well-watered region. There has been in Texas, as well as throughout the whole of the Great Plains region of the United States, a belief, founded upon hope and the representations of interested land agents, that the rainfall would increase as settlement progressed and tracts were brought under cultivation. In the subhumid region the annual fluctuations of water supply are always relatively large, but no permanent increase is shown by official records. The average distribution of rainfall in the western part of the State is favorable for agriculture, 19 per cent of it coming in the spring and 36 per cent in the summer, but in spite of this the crops are often either a total or a partial failure. In the country near the arid line this is the case about three years out of every four, because of the fact that a drought almost invariably occurs during the growing season, rendering useless all of the rain that falls afterwards.

Another cause of delay in irrigation development has inhered in the customs of the people. Their chief interests have been in cattle, and the results of so many years of nothing but stock raising have left them with neither the knowledge nor the inclination for the laborious occupation of the farmer.

But the principal bar to the spread of the industry has been the unsatisfactory condition of the laws relating to it. So long as the common-law doctrine of riparian rights was recognized as the only one having any force in the State, irrigation on a large scale was out of the question. At common law the riparian proprietor is entitled

to have the water flow through his land in quanity and quality as it was wont to do when he acquired the title thereto. There have been several instances in the past where progressive men who wished to use the water from some stream on their lands were prevented by actions brought or threatened for infringement of the riparian rights of the owners of the property lower down.

In 1875 and in 1888 laws were passed by the legislature for the encouragement of irrigation enterprises, but in both cases they proved inadequate. In 1895 the twenty-fourth legislature passed a new law regulating "the aquisition and use of water for irrigation, mining, milling, the construction of waterworks for cities and towns, and for stock raising." This law applies only to those portions of the State in which "by reason of the insufficient rainfall, or by reason of the irregularity of the rainfall, irrigation is beneficial for agricultural purposes." By this law the unappropriated waters of the above-mentioned portions of the State are declared to be public property, and provision is made for the appropriation of the same by private persons or corporations for the uses mentioned above. The riparian rights of a person owning property along such waters are recognized to the extent that the waters can not be diverted to his prejudice without his consent, or without condemnation proceedings carried on in a manner similar to those used in obtaining land for public purposes. The appropriator first in time is first in right. The law provides ample means for certifying to the appropriation and for regulating and protecting the corporations which may be organized for the purpose of using the waters thrown open to use by it. This middle course, in regard to the doctrine of riparian rights, is that adopted in California, Washington, and Oregon, and seems to have been successful in those States.

In 1897 there was passed by the twenty-fifth legislature a joint resolution to amend the constitution of the State by adding thereto a section which provides for the formation of irrigation districts without regard to county lines. Under the terms of this such districts could only be formed west of a line drawn through the State in a general north-south direction at about the eastern boundary of what is here described as the semiarid region. This amendment proposed that irrigation districts should be bodies corporate and have all of the rights and liabilities of ordinary irrigation corporations. They might issue bonds to cover cost of construction of their irrigation works, subject to the same restrictions as county and city bonds. The indebtedness for the construction of irrigation works in these districts could be created only by a vote of the majority of the landowners resident in the district and having lands susceptible of irrigation by the proposed works. The proposed amendment was submitted to a vote of the people at a special election on August 3, 1897, but was rejected by a heavy majority.

THE USE OF WATER.

The "duty of water" is the term used to express the relation between the quantity of water used in irrigation and the area upon which it is employed. The present duty of water in Texas can not be ascertained with the data in hand, but is in most cases very low. The duty assumed by most of the projectors of new irrigating enterprises is 100 acres to the second-foot. This, in the semiarid section at least, ought to prove sufficient, for by the time the amount of land under irrigation from each canal reaches the maximum the people will have learned how to use the water more economically than at first, and the land will not require so much. A careful estimate of the amount of land under irrigation in Mexico, just across the international border at Eagle Pass, gives a duty of 137 acres to the second-foot. There the crops are mainly corn and cotton, the latter needing very little water.

The investigations upon which this discussion is based revealed the fact that there are in the State not only a great variety of gravity systems of supplying water but also all kinds of pumping devices operated by steam or gasoline engines and by water wheels or windmills. The latter are of more importance than the data obtained would seem to indicate. Throughout the arid and semiarid regions nearly every residence has its windmill to pump water for domestic uses, the surplus of which is often used to irrigate a few vegetables or fruits around the house. Although a small area is watered by each mill, yet the aggregate must be considerable. Data were obtained from the few plants constructed for irrigation use only, which will give an idea of the comparative merits of windmills as a source of irrigation. The least cost of a windmill-irrigation plant was found to be a little over $16 for each acre irrigated, the largest area watered by one wheel being 30 acres. This is in the humid portion of the State. In the arid portion half that amount is all that can be supplied. The average cost is about $47 for each acre irrigated, and the area commanded by each wheel amounts to only about 7 acres.

The number of acres irrigated from each steam or pumping plant varies from 5 to 1,000. The cost of these irrigation plants ranges from $15 to $50 for each acre irrigated. The efficiency of most of the pumping plants could and should be very largely increased. There is a great lack of experience shown in the management of many of them, and consequently they have not been operated at anything like their full capacity or made to pay a reasonable dividend on the money invested. Few of them have reservoirs into which to pump the water; thus they can be used only while the actual irrigation is going on, whereas to be operated economically they should be run day and night, at least during the irrigating season. There are

a number of plants in the State with a capacity of as much as 2,500 gallons of water per minute. Such a plant, if worked to its full capacity, will give a stream equal to 5.57 second-feet. Allowing one-third for loss by seepage and evaporation, there is left 3.7 second-feet. The usual duty of water is estimated at 100 acres to the second-foot, but in new irrigation districts it very often amounts to only half as much. Even with this low estimate there should be more than 180 acres irrigated from the plant. Such a plant, it is estimated by H. M. Wilson, can be erected for $5,000; this will give a cost of $28 per acre irrigated.

For estimating the quantity of water used in irrigation, various units of measurement are employed. For bodies of standing water the cubic foot, or, where that is too small a unit, the "acre-foot" is used. The latter is the quantity of water that will cover an acre of ground 1 foot deep, or 43,560 cubic feet. The gallon is also very largely used for stationary bodies of water and for pumping plants, especially those for municipal supply. In considering flowing water some unit must be used which expresses the capacity of the stream in a given period of time. That most commonly used is the second-foot, or the number of cubic feet of water which flow by in a second of time. The "miners' inch," so generally quoted in California and Colorado, is not used in this State. In the following table are given some convertible units of measurement:

Units of measurement used in irrigation, with equivalents.

1 cubic foot = 0.0283 cubic meter = 7.48 gallons.
1 cubic foot of water weighs 62.4 pounds.
1 second-foot = 449 gallons per minute = 26,930 gallons per hour.
1 second-foot = 50 California miners' inches.
1 second-foot = 40 Arizona miners' inches.
1 second-foot for one day = 1.9835 acre-feet.
1 second-foot for one day = 646,317 gallons.
1 second-foot of water falling 10 feet gives 1.135 horsepower.
1 horsepower is given by 1 second-foot of water falling 8.8 feet.
1 gallon of water = 231 cubic inches = 0.13368 cubic foot, and weighs 8.34 pounds.
1,000 gallons per hour = 0.037 second-foot.
1,000,000 gallons = 3.07 acre-feet.
1,000,000 gallons per twenty-four hours = 1.55 second-feet.
1 acre = 43,560 square feet, or nearly 209 feet square.
1 acre-foot = 325,850 gallons.

DISTRIBUTION OF RAINFALL.

The most important element of climate in its relation to the present discussion is precipitation. In Texas the rainfall is greatest in the eastern portion of the State and decreases steadily toward the west. This decrease is at the rate of about 4 inches every 60 miles, being about 50 inches in the extreme east and 9 inches at El Paso. The

isohyetals, or lines of equal precipitation, run through the State in a general north-south direction, as shown by the map, fig. 1.

The customary definition of "arid region" is one having less than 20 inches of mean annual rainfall. This, however, is not sufficiently complete, for it does not take into account the distribution of the rain throughout the year. In certain parts of the country, where the greater portion of the precipitation occurs during the crop season, wheat and other cereals are successfully raised when the rainfall is far less than 20 inches; while in other parts of the United States, as,

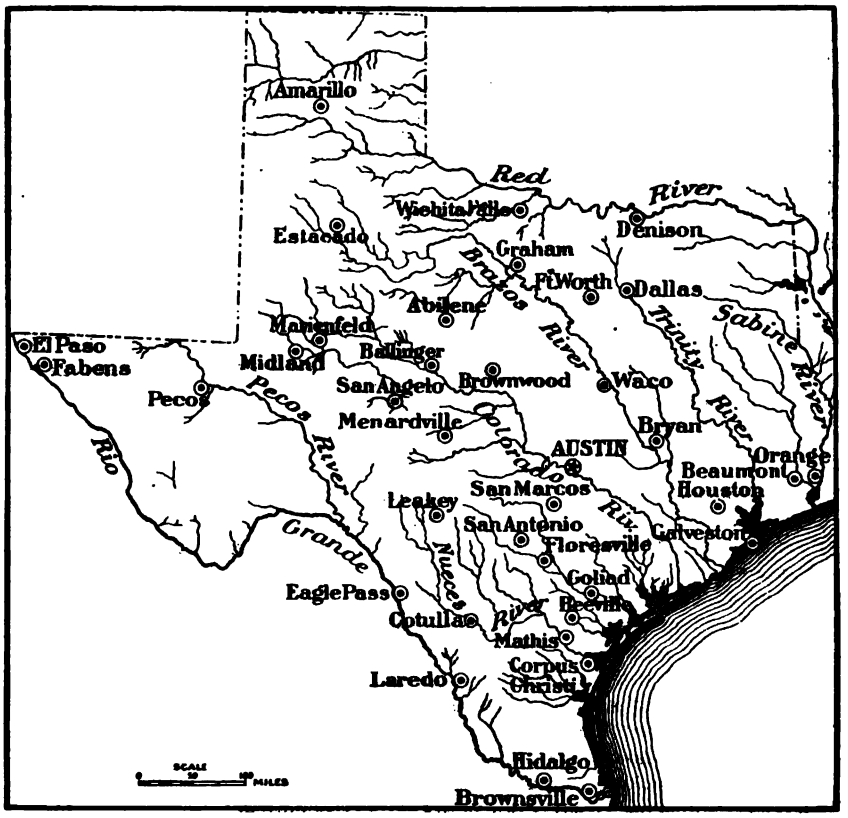


FIG. 1.—Index map of Texas.

for example, near the Pacific coast, where the greatest precipitation occurs during the winter months and the summers are practically rainless, irrigation is necessary during a part, at least, of the crop season. Thus the distribution by months is almost as important an element as the total quantity occurring during the year.

The accompanying diagram, fig. 2, shows the quantity and average distribution of rainfall by months at a number of selected stations fairly typical of the State as a whole. The first of these is Galveston, on the coast, in the eastern part of the State. Here the average

rainfall for twenty-seven years is 49.6 inches. As shown by the diagram, the months of heaviest precipitation are September and August, but in every month except February an average of over 3 inches of rain has fallen. This is fairly typical of the distribution of rainfall along the Gulf coast. The diagram next above this is for Austin, where the average rainfall for thirty-nine years is 33.4 inches. Here, also, there is an excess of precipitation in September, and a second maximum in May. Relatively to these months, June, July, and August are somewhat dry; but in every month throughout the year there has fallen an average of over 2 inches of rain.

The next diagram in fig. 2 above that for Austin is that for Fort Clark or Brackettville. This is constructed from the average for twenty-nine years. The mean annual rainfall is 22.7 inches. Fort Clark is remote from the coast, and the distribution of its rainfall, though somewhat similar to that at Austin, having maxima in September and May, shows reduction in quantity, especially during the winter months. Next above the diagram for Fort Clark is that for Fort Elliott, situated far up in the Panhandle of Texas, near the Oklahoma line. Here the quantity and distribution are fairly typical of the Great Plains area. The diagram is derived from the mean of observations extending over eleven years and giving an annual average of 23.2 inches. The month of greatest rainfall is May, September being below the average. The rainy season may be said to extend from April to August.

In the upper part of fig. 2 are two diagrams illustrating the typical distribution of rain in Trans-Pecos Texas. This has been named by General Greely the Mexican type of rainfall.[1] In these, particularly in the diagram for Fort Davis, obtained from twenty-six years' observations, the rainfall is seen to increase regularly from February to August and then to decrease rapidly to the end of the year. The greater part of the precipitation occurs during

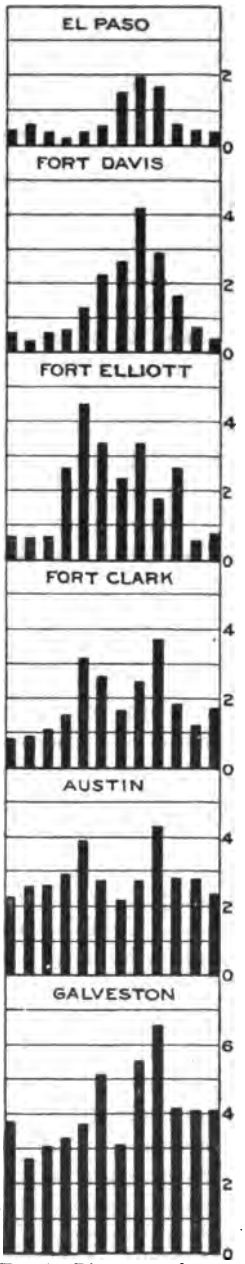


FIG. 2.—Diagrams of mean monthly rainfall at six stations.

[1] Nat. Geog. Mag., Vol. V, 1893, p. 51.

June, July, August, and September, at the time when most needed by many crops. The diagram for El Paso, from thirty-six years' averages, shows a relatively uniform but small precipitation throughout the year, with the exception of the months of July, August, and September.

CLIMATIC AND GEOGRAPHIC DIVISIONS.

In order to discuss the present condition and development of irrigation in Texas it is essential to pursue some systematic order of arrangement based upon climatic or geographic factors. The simplest arrangement is that of taking first the humid region, or that having 40 inches or over of rainfall; next the subhumid, with from 30 to 40 inches; then the semiarid, with from 20 to 30 inches of rain; and last the more arid portions, having less than 20 inches of annual precipitation, this being in the western part of the State, and including the Panhandle and Trans-Pecos regions. The greater part of the irrigation works are, however, in the southern half of the State, or near the coast, and these divisions, especially those of subhumid and semiarid, extending, as they do, in a north-south direction, though simple, do not afford a wholly satisfactory grouping. In the central part of the State the irrigation works are small, and there is no essential difference between those in the more humid and those in the semiarid areas. In fact, the actual amount of annual precipitation has less to do with the necessity for artificially applying water than the local conditions of soil and character of crops.

From the above-mentioned conditions it has been found desirable to adopt a somewhat arbitrary classification, based partly upon the distribution of rainfall and partly upon geographic position. In the following pages, therefore, a description will first be given of the irrigation plants in the humid area near the coast, particularly those lying within 50 miles or more of Galveston. Next in order are the small irrigation projects scattered about the center of the State from the humid areas east of Brazos River westward nearly to the borders of the arid region and southward to the vicinity of Austin and San Marcos. The third division is taken to include the old irrigation works at San Antonio, with small irrigation projects found at intervals down to the coast. Next in order to these are the irrigation works planned or constructed along the Nueces River and the lower Rio Grande. The fifth division to be considered is that of the Llano Estacado and adjacent areas, including the greater part of Panhandle Texas; then the lands watered by the Pecos River, and finally the irrigation works in Trans-Pecos Texas, extending to the extreme westerly end at El Paso.

DESCRIPTION OF IRRIGATION WORKS AND PROJECTS.

EASTERN GULF COAST REGION.

The humid part of the State may be considered as that having a mean annual precipitation of 40 inches or more. This comprises the greater part of the State east of the city of Dallas and of the lower Brazos River. The rainfall over this area is usually abundant, and irrigation in the northern and central portions of this humid region will not probably become of any considerable importance, but in the southern end, along the coast, there exist large tracts of land adapted to rice growing, and the greater portion of this will probably be used for this purpose.

This land is mostly a flat prairie, locally called swale land, covered with a coarse growth of grass and having such a gentle slope toward the sea as to be but little removed from a marsh during a large part of the year. It extends inland for several miles and is cut by numerous bayous, in which the tides from the Gulf ebb and flow and the waters gradually become brackish as they near the Gulf. Most of the rice farms lie along these bayous, and from them the principal supply of water is derived. The farms are so located as to insure a supply of fresh water. The soil along the bayous is much richer than the prairies and yields heavier crops.

The manner of cultivating and irrigating is very different from the South Carolina system, where the water is held by artificial storage reservoirs or raised above the level of the fields by the action of the ocean tides, which back up the flow of the rivers at each tide to a height sufficient to reach the fields. In this part of Texas storage reservoirs are used in only a few cases, most of the fields being supplied by pumps placed on the banks of the bayous and operated by steam power. The land is laid off in much the same way as on the eastern plantations. The work in this State is newer and therefore rougher, but the main features are the same. The fields are surrounded by low levees to hold the water on the land, and are ditched to permit drainage at the lowest point.

Nearly all of the land planted with rice is irrigated, as those who have attempted to grow it without irrigation have lost their crops two years out of five and made only very short crops during the other three years. As previously stated, the water is supplied to the fields by pumps run by steam power, rotary pumps of the Menge pattern being most frequently used. These are operated by engines of from 10 to 70 horsepower or more, and have a pumping capacity of from 1,500 to 8,000 gallons per minute, or from 3.34 to 17.82 second-feet. The lift varies from 9 to 12 feet, and the pumps are run night and day during the irrigating season, which lasts from sixty to ninety days, thus delivering from 400 to 3,000 acre-feet of water. For the prairie farms the water is carried in canals, either on the surface or

excavated but little below it and confined by levee walls on each side, for a distance sometimes of 1½ miles.

The area in rice is increasing rapidly. One planter, Mr. J. E. Broussard, of Beaumont, has 750 acres this season (1897), whereas last season he had but 250 acres. He estimates that the total area watered from Taylors Bayou alone, in Jefferson County, in 1897, was 8,500 acres. From his statements the following facts were derived: Planting of early rice is begun in March, from about the 15th to the 25th, if ground and weather are suitable, and continued until the 1st of June. Many persons plant as late as the 15th of June, but this is probably too late to make a good crop. As soon as the rice is up to a height of 6 or 8 inches, if the ground becomes too dry for it to grow well, the usual practice is to give it a good soaking, but not to hold the water very deep upon it the first time. As soon as the rice becomes well rooted, the land is flooded and the attempt is made to keep it in this condition until the rice is ready for harvest. Most farmers turn the water off about two weeks before harvesting, although there is considerable difference in this matter. The size of field inclosed under each set of levees depends altogether on the lay of the land; if very level, there may be as much as 50 acres in one "cut," but where the land has much fall the average piece under one set of levees will be about 5 to 8 acres. The lands are so level that when the water is from 4 to 6 inches deep over the lowest part it will wet the highest portions. The depth of flooding rice in this section is about 5 or 6 inches; some farmers prefer deeper water, while others do not care for so much. Experience has shown that when water is held very deep on rice all the time the quality of the grain is not so good; it is sufficiently heavy but is somewhat "chalky." There are several farms that have from 500 to 1,000 acres under cultivation in rice. The average yield is reported to be 40 bushels to the acre of rough rice, or 10 barrels of clean. One hundred pounds of rough grain will make about 72 pounds of clean rice.

Mr. F. H. Catron, of Orange, has been one of the most successful planters. He has been irrigating since 1891 with a Menge pump, operated by a 50-horsepower steam engine, pumping from a bayou into a surface ditch 1 mile long and 20 feet wide, the lift being about 8 feet. The total cost of the canal levees and ditches was $5,000, and the engine and other parts of the pumping plant cost $1,500. The pumping capacity is 5,000 gallons per minute, or 11.14 second-feet. In 1896 he irrigated 500 acres of rice.

Irrigation of orchards and gardens is resorted to in this humid region, particularly in the vicinity of Galveston and Houston. This is due largely to the fact that artesian water can be had, and the land is so nearly level that water can be readily applied. In spite of the abundant rainfall, experience has shown that fruit and garden crops are greatly improved in quantity and quality by the application of

moisture during a portion of the year, particularly at times of summer drought. Operations on a considerable scale have not been attempted, but many small gardens are being watered. Nearly all of this land requires drainage, and this is especially the case when irrigation is introduced. The prairie land in this region is not notably rich, but it is easily worked, and as a rule ground water is near the surface.

The source of water for the city of Galveston is at the suburban town of Alta Loma, 18 miles distant from Galveston. Here are 27 wells 7 inches in diameter and 3 wells 9 inches in diameter, from 750 to 850 feet deep, all located in a direct north-south line, 300 to 750 feet apart, making a total distance from end to end of 16,350 feet. The wells, at 2 feet above the ground, showed a static pressure of from 5 to 7 pounds per square inch. Water is derived from several horizons, and the combined flow is 12 million gallons per day, or 18.60 second-feet. The pressure is sufficient to deliver 5 million gallons daily, or 7.73 second-feet, at the city of Galveston, 18 miles away, through a 30-inch pipe having a fall of 1 foot to the mile. A portion of this 30-inch pipe is depressed about 10 feet for a distance of 2½ miles, from the mainland to the island, under West Galveston Bay. These wells have been flowing for three years. The cost for the installation of the entire plant was $790,000. Analysis shows that the water is usually pure, and the people of Galveston are highly gratified in having a water supply of such excellence.[1]

The water-bearing strata underlying this portion of Texas are so uniform in character that contractors do not hesitate to guarantee a flow of from 25,000 to 50,000 gallons daily, or 0.04 to 0.08 second-feet, for a specified size of well at any point in or near Galveston County. There are 5 artesian wells at and about Clear Creek, 1 at Shell Siding, 10 in the vicinity of Dickinson, 2 at North Galveston, 1 at Texas City, several at Hitchcock, 2 or 3 at Alta Loma in addition to those already mentioned, and 2 at Arcadia, making a total of not fewer than 55 for the county. In some localities sufficient flow for smaller wells is obtained at a depth of 490 feet, though occasionally the extreme depth of from 1,000 to 1,100 feet is required.

Water for irrigation is also provided by using windmills. There is a stratum of water-bearing sand at a depth of from 30 to 60 feet which furnishes an abundant supply for irrigation by the smaller land holders and market gardeners. For example, Mr. H. Sampson, an orchardist near Alvin, has a surface well 12 inches in diameter and 36 feet deep, in which he put an 8-inch tubing. He asserts that from 15,000 to 30,000 gallons can be pumped from it daily by a windmill of sufficient size. Within the town limits of Alvin, Mr. W. H. Nash has a similar well which he states has never been pumped dry by a 10-foot windmill. He irrigates all the berry and garden crops which he

[1] Engineering News, Vol. XXXIX, No. 9, March 3, 1898.

thinks it advisable to grow in between the trees of a 10-acre bearing pear orchard.

This will convey a brief but positively reliable idea of the underlying water supply of the Texas coast for irrigation purposes. It remains to add a word concerning the use of water for irrigation purposes in this section. The structure of the soil is somewhat peculiar in that it is naturally subirrigated; that is to say, there is plenty of water within from 7 to 15 feet of the surface. An ordinary barnyard well does not exceed in most instances 10 to 12 feet in depth. Almost all the varieties of trees planted in the orchards here readily send their roots to this and greater depths, and hence for commercial orchards irrigation is not essential. This is especially true if timely, judicious, and frequent cultivation be given. With the berry grower and market gardener the conditions are different. His crops must be made within a specified period to obtain the best results and greatest returns. To accomplish this it is essential that a good supply of water be at command to force the crops when conditions of great heat and drought develop. At the same time it should be noted that perhaps 90 per cent of the berry growers and gardeners have not yet provided irrigation works, and they have been, in a measure, doing business with a small but very uncertain margin of profit. They have hoped each year that it would not be necessary for them to irrigate. Two successive seasons of drought, however, have induced them to prepare to avail themselves of the ample supply of water. Within two years from this time probably the greater part of the most intelligent berry and truck growers will be fully equipped with an irrigation plant of some description.

The advantages of having irrigation facilities were abundantly illustrated in 1896. Those who had such equipments were not only selling more products at the same time that their neighbors were offering theirs, but were selling long and profitably after their less fortunate competitors could not produce sufficiently to make an attempt at marketing advisable. This is especially noteworthy in the case of the strawberry growers in the coast country.

CENTRAL TEXAS.

This second division has been arbitrarily drawn to include the irrigation plants, mostly small in size, situated within the central part of Texas, from about the vicinity of Brazos River westerly to the edge of the arid region, and from the vicinity of Austin, on the south, northerly through the State. This area falls between the lines of mean annual precipitation of 20 and 40 inches, and thus includes the tract of country having sufficient rainfall to raise crops in ordinary seasons. The precipitation is fairly uniformly distributed by months, as shown by the diagram of mean monthly rainfall at Austin in fig. 2 (p. 23). The black, waxy soil which covers a considerable portion of

this district is retentive of moisture and resists droughts, as does the land along the Brazos and Colorado river bottoms, located mainly within this area. The region to the south and southeast of Austin, although having the same mean annual precipitation, has not been included in this division, because the rapidly increasing temperature toward the Gulf, as well as the different character of the soil, renders irrigation somewhat more essential and its development is more nearly comparable to that of the arid region to the west.

In this central portion of Texas, where crops are raised successfully each year, irrigation is not felt to be a necessity except by truck farmers and nursery men, and many of these have introduced it in a somewhat experimental way. The results, however, demonstrate its value, and this method of cultivating the soil is being extended. Water is usually obtained from a well or small storage reservoir, and pumped by means of a windmill, or occasionally by a small steam engine.

The most easterly of the irrigation works in this section are those at Mexia, near the head of Navasota River, a tributary of the Brazos, and near Bryan, on Brazos River, at the State Agricultural and Mechanical College. At this latter point storm waters are impounded in a reservoir formed by building an earthen dam 10 feet in height and 100 feet long across a small draw. This covers about 1 acre, and from it so far about 7 acres have been regularly irrigated, the crops watered being garden truck and alfalfa. In addition to the storm waters, the reservoir is so situated as to receive the waste water from the college ice factory and from the natatorium when necessary, but as this water, coming from an artesian well, carries in solution considerable mineral matter, it is not allowed to enter the reservoir to any considerable extent.

At Mexia, in Limestone County, J. W. Stubenrauch has been very successful in the use of a small irrigation plant for fruits and vegetables. This consists of a dam across a ravine, catching the storm waters and forming a tank covering about an acre of ground. From this the water is lifted to a height of 25 feet by an 8-foot windmill into an earthen reservoir 50 feet long and 100 feet wide. This reservoir is now being enlarged to have double the present capacity. The total cost of the system was $300, including 700 feet of piping; 7 acres have been irrigated, but it is estimated that 15 acres could be watered. Mr. Stubenrauch is also putting in another system with a reservoir covering an acre of ground, the dam having a height of 5 feet above the outlet pipe, for filling which he will use a 12-foot wheel. This he expects will enable him to irrigate 30 acres at one time. He states that the total cost, including 600 feet of 2½-inch pipe for discharging the water into the reservoir, was $485. He pumps from a storage tank made by damming a big ravine.

In the northern end of this district—that is, north of the Colorado

River—irrigation is little practiced. There is a well-developed plan to irrigate a large tract of exceptionally fertile land in the Wichita River Valley. The storm flow of this river is to be stored at a favorable site about midway of its course. The catchment area above this storage basin will be about 1½ million acres. The area to be irrigated is about 270,000 acres.

Careful flood-flow determinations indicate that the supply is largely in excess of requirements. The region has a rainfall of about 28 inches, which it is necessary merely to supplement. That is, the duty of water here will be comparatively large. In fact, the greater part of the area is at present utilized as farm land. But, though the lands are rich and easily tillable and the average yield is considerable, there is yet a disastrous variability of yield on account of droughts. Therefore, relating to a subhumid rather than to an arid region, the project will have this advantage over irrigation undertakings in the

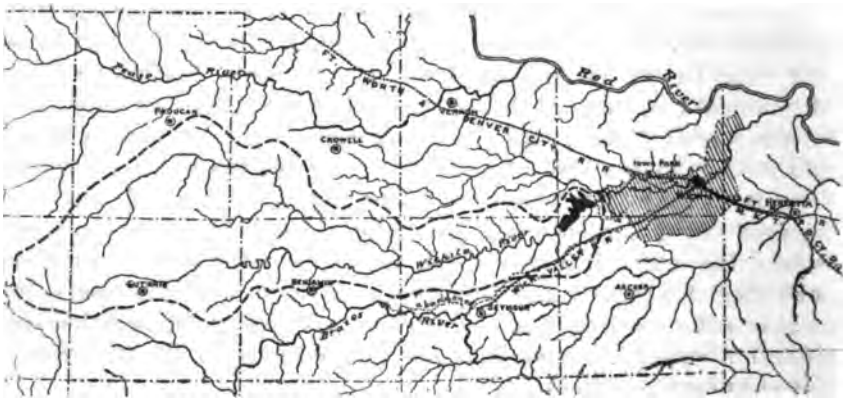


FIG. 3.—Map of drainage basin of Wichita River.

arid lands proper, that the amount of water needed for abundant crop yield is comparatively small. The plan, which has been developed fully, is based upon careful and elaborate engineering work. Before the present reservoir site was chosen, other possible sites, along the Pease River to the north and the Brazos River to the south, were examined with a view to diversion of these streams to the same lands. The present selection appears to be an exceptionally fortunate one. The depth to bed rock at the dam site is slight and the river valley here is constricted to a canyon.

The dam is to be of earth, 80 feet high, designed to hold water to a depth of 70 feet. Both spillway and outlet are to one side, well away from the dam—the spillway over bed rock, the outlet through a tunnel in bed rock. The capacity of the reservoir will be about 12,000 million cubic feet, or about 275,000 acre-feet. There will be two canals, designed to irrigate both slopes of the Wichita Valley. At their head these canals will have a width at bottom of 40 feet, a depth

of 8 feet, and a grade of 1 foot to 5,000 feet. The total cost is estimated at a little over $1,000,000.

Careful determinations of flood flow made by the company's engineer, Murray Harris, indicate that the supply is much more than ample. They are as follows:

	Acre-feet.
During the first week in January, 1897, about	59,687
From March 28 to April 4, 1897, about	98,714
From April 25 to April 29, 1897, about	174,472
From April 29 to May 15, 1897	330,579
Total	663,452

Farther south, near Brazos River, in Young County, not far from Graham, are reported two small gardens irrigated by windmills, such as are found scattered all through the semiarid region.

The Lytle Water Company, in 1897, began to build a dam across Lytle Creek at Abilene, in Taylor County, the main object being to furnish good water to the town, but it is also expected to irrigate 300 acres by a canal 1½ miles long. The dam is of earth, riprapped with rock on the inner slope and sodded on the outer. It is 800 feet long, raises the water 15 feet, and has a masonry spillway of 300 feet. The total cost of the plant will be about $25,000. The reservoir formed by the dam will cover 120 acres and have a capacity of 300 million gallons, or 920 acre-feet.

On the ranch of Hugh Lewis, 8 miles north of Ballinger, in Runnels County, is a stone dam built in 1896 across a small creek which originates in a spring a short distance above. The dam is 80 feet long, raises the water 6 feet, and supplies a ditch some 200 yards in length. Ten acres in fruit and vegetables were irrigated in 1896, but at least 50 acres could be covered. The total cost was from $150 to $200.

In Tom Green and Irion counties the water facilities furnished by the Concho River and its numerous branches and tributaries are among the finest to be found anywhere. These have only been partially used by individuals and small companies in separate systems, making the cost of maintenance much greater than if consolidated. Nevertheless, they have been fairly successful, and have certainly reduced the cost of living in that section, making foodstuffs, especially vegetables, much cheaper and more abundant. There are ten of these plants reported in those two counties; three on the South Concho, one on the Main Concho, and two each on the North Concho, Spring Creek, and Dove Creek. The total area irrigated is 3,200 acres, 2,000 being in Tom Green County and 1,200 in Irion County.

The plants of C. B. Metcalfe, of San Angelo, and J. J. Glenn, of Water Valley, may be taken as types of the systems in vogue. Mr. Metcalfe's canal takes its water from the east bank of the South Concho River 12 miles south of San Angelo. It is 4 miles long, with

an average top width of 12 feet, bottom width 8 feet, and depth of water 1.5 feet. It was begun in 1887 and the first mile was completed the next year, but it was not entirely completed until 1896. It takes its water by means of a brush-and-stone dam 200 feet long and 7 feet high, which extends across the river and cost about $500. The main ditch cost $500 to the mile, and the laterals, of which there are three, cost $250 to the mile, making a total cost, with incidentals, of $7 to each of the 470 acres now irrigated. The repairs, which are maintained by the tenants, may be estimated as amounting in labor to 75 cents per acre. The crops irrigated in 1896 were: Johnson grass, 40 acres; cotton, 120 acres; corn, oats, wheat, truck, etc., 220 acres; total, 380 acres.

The ditch of J. J. Glenn is located on the North Concho 1½ miles west of Water Valley, and is 3 miles long, 8 feet wide on top, 4 feet wide on bottom, and 2½ feet deep. It was first used in 1886, and is supplied with water by a rock dam across the river, 100 feet long, with an average height of 8 feet. The total cost of the system was $3,500, and it commands 350 acres, of which 250 have been irrigated, two-thirds in cotton and the remainder in the different sorghums and oats.

The most successful field crops in this region are oats and cotton, the former producing from 30 to 90 bushels with great certainty, and the latter usually 1 and sometimes 1½ bales to the acre. Corn is a poor crop, by reason of the dry winds, but sweet potatoes, melons, and celery do very well, especially the last named.

In Sterling County there are two systems on Concho River, only one of which has been reported in full. It is located 5 miles from Sterling City and is owned by the McGee Irrigation Company. The main ditch is 2 miles long, has a top width of 6 feet, is 4 feet wide at the bottom, and carries about 1 foot of water. It was begun in 1892 and first used in 1894. The water is raised by a loose-rock dam, 125 feet long and 6 feet high, built across the river. The total cost was $1,500, and it commands 250 acres, only 75 of which are really irrigated. The principal crops, in the order of their importance, were cotton, corn, sorghum, oats, sweet potatoes, alfalfa, and vegetables. Repairs are maintained by each stockholder doing his share of the work on the ditch.

At Brownwood, in Brown County, about 120 miles east of the above works, considerable interest has been taken in irrigation during the last few years, there being a large area well located for irrigation on a considerable scale. This scheme was abandoned for lack of capital to complete it. Meanwhile several steam pumping plants have been erected for irrigating smaller areas. The most important is that of the Swinden Pecan Orchard Company. This consists of a centrifugal pump operated by an 80-horsepower engine and pumping 3,000 gallons per minute, or 6.84 second-feet. The water is carried by a flume

4,000 feet long to a reservoir formed by building an earthen dam 4,000 feet long and with a height varying from 2 to 15 feet. The dam is at the foot of gently sloping land, and forms a triangular reservoir covering 55 acres. The reservoir is designed to irrigate the 400 acres of level land lying between it and Pecan Bayou, from which the water is pumped to fill it. A small stream is also dammed and turned into the reservoir. The 400 acres commanded by the reservoir are planted in pecan trees, making the largest orchard of this kind in the world. The irrigation plant was put in mainly to enable the owners to practice truck farming and small fruit growing between the rows of trees while waiting for the latter to mature. The soil is a rich black and chocolate loam. The great mistake that has been made in this plant is in having the reservoir so large and shallow. Evaporation and seepage are in this way so increased as to become a serious source of loss.

Immediately east of this, in Mills County, are several pumping plants on Colorado River. That of J. B. Baker, 11 miles southwest of Goldthwaite, was completed in 1896, and consists of a 32-horsepower boiler operating a Worthington pump. The plant cost $2,000, and the expense of operating it is about $7 a day of twelve hours. It has a capacity of 1,220 gallons per minute, or 2.72 second-feet, and commands 80 acres, 75 of which were irrigated. The crops raised were corn, cotton, and oats. J. D. Willis, of Ratler, has attached pumps with a capacity of 50 gallons per minute, or 0.11 second-foot, to the shafting of his gin and grist mill, irrigating 5 acres in fruits and vegetables. The power is furnished by a turbine under a 5-foot head of water from a dam 300 feet long across Colorado River. At Regency, G. W. Alldridge, with a 20-horsepower engine, pumps 450 gallons per minute, or 1 second-foot, and reports that he can water about 5 acres per day, which would give 50 to 75 acres under command of his pump. None of these men use reservoirs.

On the south side of Colorado River, in San Saba County, J. H. Lindsey owns a steam pumping plant on the river, 20 miles north of San Saba. It consists of a 30-horsepower engine and a pump with a capacity of 840 gallons per minute, or 1.87 second-feet. The plant cost $2,000 and is worked eleven hours a day at an expense of $3, irrigating 40 acres in corn and cotton. There are also several small areas irrigated in this county from the numerous springs which issue from among the hills. The total amount of these is 250 acres. Farther down the river, in Burnet County, the only irrigation reported is one windmill irrigating a garden 50 feet long and 150 broad, and also 1¼ acres watered by a spring and reservoir. Both are very successful.

At the head of San Saba River, in Schleicher County, William L. Black has been irrigating since 1894 with a plant consisting of a 6-horsepower engine, pumping 580 gallons per minute, or 1.29 second-feet, and a 6-foot overshot wheel with a capacity of 167 gallons per

minute, or 0.37 second-foot. The latter is run day and night, no reservoir being provided, and the total area irrigated is 50 acres, in corn, potatoes, and sorghum. With his water wheel he uses four 10-inch cylinders worked horizontally, and with the engine a link-belt box elevator, which gives satisfaction. Farther east, in Menard County, on San Saba River, is a pumping plant owned by Emile Vanderstucken and consisting of an 18-horsepower steam engine operating by a belt a Menge centrifugal pump with a capacity of 1,167 gallons per minute, or 2.60 second-feet. The total cost of the plant was $1,500. No reservoir is used, the water being carried in a flume to the highest point on the land and distributed by ditches. On account of the abundance of rain in 1897 it was used but very little. In 1896 it was operated from March to September, irrigating 100 acres and making good crops, with practically no rain.

The following description relating to the condition of irrigation in the vicinity of Menardville is taken from a statement prepared by Mr. Robert S. Dod, of Brady, Texas, county surveyor of McCulloch County. This method of agriculture has been a great success in this vicinity, as is evident to anyone passing through the county examining the fields and conversing with the farmers. The system has not always been successful, but early failures were mainly the result of inexperience and arose from accidental and not from essential defects. Mistakes have been gradually remedied, and by well-directed energy and enterprise great improvements have been brought about, progress being still made toward even better methods.

On crossing San Saba River 5 miles below Menardville, the traveler enters upon the irrigated part of the narrow valley lying between the river and the low hills, and is impressed by the signs of energy and activity. The fences are good and in repair; the gates have two hinges and swing clear of the ground; the fields are clear of grubs and clean of weeds; the ditches are straight and well shaped and clean; the cotton as seen when visited stood 28 to 30 inches high all over the fields, of good color and as clean as possible. The corn was 10 feet high or over, and the dark green of its leaves was accounted for by the water running in the furrows at its roots. To the right was an orchard of peach trees filled with fruit, and beyond this a stubble field already plowed and harrowed, ready for reseeding for another harvest. Near this field stood the stacks, the proof of the success of that crop at least, yielding their stores of grain to the efforts of the busy crowd about the thrasher. The active movements of the men at work there and in the neighboring fields, and the rate at which the teams traveled carrying the grain to the barn and returning to the field, showed that the success apparent everywhere was due to systematic, well-directed effort—the kind of effort that men put forth when reasonably certain of the reward of their labor. Such animation men do not display when disappointment and failure year after year have sapped

their energy and made them cynically hopeless of success, when under "dry farming" they have degenerated into the almost brutish attitude of contentment with surroundings that could be improved and toleration of losses that might be avoided.

All the way from the river to Menardville the road passes through irrigated farms showing success in proportion to the amount of care and labor expended on them. The vegetable gardens, the orchards, the green lawns, and the flowers and vines around the houses make this valley the picture of contented prosperity. The farmers with whom conversation was had gave many facts applicable in contrasting their methods and results with those of the dry-land farmer. They raise from 1 to 2 bales of cotton per acre, the difference in yield depending largely on how much damage the worms do in a given season and how much rain falls in August. The drier this month the better the cotton crop. On new land with few worms and a dry August 2 bales would be expected. Their corn yields from 40 to 80 bushels per acre. One man suggested that a light rain or shower was needed when the pollen was ripe in order to obtain the best results. Oats yield from 50 to 80 bushels per acre. During the years from about 1888 to 1895 the farmers irrigating in Menard County were raising from 1 to 2 bales of cotton to the acre, 40 to 50 bushels of corn, and 80 or more of oats, while in contrast to this their neighbors without irrigation were working perhaps equally as hard, bringing together what little cane and fodder could be raised to save the stock from starving to death, and producing only enough marketable stuff to keep the interest on the mortgages paid up, and perhaps not even that.

These beneficial results are produced by a little water and a deal of hard work. The water rate is $2 per inch, and 1¼ inches will irrigate an acre of their land, so that $2.50 per acre and a little extra work make the difference between one-third of a bale of cotton and 2 bales; between no corn and 40 to 50 bushels; between 80 bushels of oats and a dead failure.

It has been proved by experience that one man can not give proper attention to more than 25 acres of this irrigated land. He will need help in cultivating if he plants corn and cotton, but could tend rather more land put in small grain. He will require for these crops a little over an inch of water per acre, and will need to turn the water on about every twenty days.

At Menardville corn and cotton are irrigated by running the water down the furrows between the rows from openings in the ditch. The amount of labor required for the operation and to make the water run properly depends upon the general level of the field and the care with which the furrows are laid off with regard to the slope. Small grain and fodder crops are laid off by throwing two furrows together, back to back, as a border, every 8 or 10 steps, to hold the water, and flooding the land between these borders. Some farmers use an Acme

harrow to finish off the land after planting, running it between the borders so that the small furrows left by it help in directing the flow of the water.

As to the amount of water required per acre, one man who irrigates 40 acres of land uses 40 inches of water, and occasionally needs a little more. On another farm they use 15 inches of water on 12 acres of garden truck. On the upper part of the ditch above town the water is measured and distributed by the inch; that is, if a man wants 20 inches of water, the gate opening on his ditch is set for a 20-inch flow and so remains through the season, giving him his 20-inch constant flow. From town down they use the water in rotation, as, owing to a mistake originally made in laying out the distributaries, the use of water above interferes with the flow below. So they alternate every seven days, those above using all the water that reaches them for that time, and then the lower owner having all the water for the next seven days; this farmer, having some 500 acres under irrigation, distributes the water over them as necessary.

The amount of water required for an acre of ground here is more than that needed for sandy fields. The soil at Menardville is a clayey loam containing a large proportion of lime. Both soils require the same amount of water for the first irrigation, but the sand packs and requires less at each succeeding irrigation, whereas it is claimed that the limy loam seems to rise instead of pack, and requires as much water for the later irrigation as for the first.

The ditch which supplies these farms is nearly 10 miles long. The dam is built across San Saba River some 4 miles above Menardville and returns to the river some 5 miles below the town. The charter was obtained by the Vaughan Agricultural and Improvement Company in 1874, and the ditch was built soon after. It is claimed that this company put $12,000 in the work. This was excessive, an extra expense being incurred by the refusal of right of way in one instance, forcing the company to make a cut 16 feet deep and several hundred feet long. Further, the methods of work were rude and costly. Wheelbarrows were used to move the dirt, and in the cut the dirt was thrown on staging and passed from man to man. There are 97 shares in the company, valued at $180 each. One year $1,200 was spent in improvement; another year $1,000 in the same way; but the ditch pays all running expenses, cost of improvements, and 10 per cent on the shares at the above quotations.

The grade of the ditch after construction was found to be irregular and unsuitable, so work has been done each year—cutting and filling, to reduce the slope above Los Mores flume to a nearly uniform grade of 30 inches to the mile. At the flume is a fall of 14 inches in 128 feet. At the point of the mountain where the ditch curves with the hill and runs through rock it is lessened in size and has a much steeper grade. The grade of 30 inches to the mile was established

experimentally, and satisfies as nearly as possible the necessity of avoiding silting on the one hand and erosion on the other. The ditch runs through coarse gravel part of the way, and there is a heavy loss from percolation.

The straightening of the ditch, reduction of the grade, and tightening of the dam have given an available flow of water sufficient to irrigate 2,000 acres of land, which is the amount estimated to be under irrigation from this ditch at the present time. This taxes the flow to its full capacity.

The dam is built of rough limestone quarried at the spot, averaging, where seen on the front of the dam, 2 by 3 feet by 10 inches, laid in courses without cement. The blocks are tied by bolts fastened to a log under the dam at the bottom and passing up through the dam and fastened at the top by taps to cross-ties lying along the top. The dam is slightly concave and is about 200 feet long and 5½ feet high at the middle of the front, with an irregular batter. It is 13½ feet wide on top at the center. It rests partly on rock, partly on gravel, and is backed with earth with a slope of nearly 2 to 1.

The water stands within a few inches of the top of the dam and runs over at every rise in the river. There must be 10 or 12 feet of water passing over it at times, judging from the high-water marks. Below the dam is a pile of loose bowlders which holds the leakage through the dam and forms a water cushion to receive the fall. The dirt is washed from the back of the dam at every high rise, and is at once replaced when the rise goes down, by scraping the dirt from the north side of the river. The dam backs the water up about 500 yards, the deepest hole being about 15 feet. The water is taken out on the south side 100 or more yards above the dam and carried in a cut to the sluice gate a little below the dam.

A section of the ditch made a few hundred yards below the sluice gate gave the following: top, 15.2 feet; bottom, 8 feet; depth, 2.7 feet; wetted perimeter, 16.5 feet; area, 29.83 square feet; maximum surface velocity, 2.17 feet per second; mean velocity, 1.54 feet per second. The velocity was measured for 100 feet above and below the section, where there was no very great difference in the dimensions of the ditch. The fall of the surface was found to be at this point 0.1 foot in 195, or 1 foot in 1,950, or 2.7 feet in a mile. This, with a coefficient of $N=0.03$, would give a velocity of 1.57 feet per second, which is very nearly the observed velocity of flow. This gives a discharge of 46 cubic feet per second, or 2,300 inches, estimating 50 inches to 1 foot.

Taking the estimated acreage irrigated as 2,000 acres, we have from our calculated flow a little over 1 inch per acre, which is the allowance in actual use, as above stated, and a water duty of 44 acres per cubic foot per second of flow for the water entering the main ditch. These measurements were made at but one point and can be considered as only approximate for the whole ditch. For accuracy they should be

repeated at a number of points and proper allowance made for percolation and leakage. In general, the estimate is that three waterings of 4 inches will make a crop. From the above it is readily seen that before a calculation can be made with any degree of certainty as to what water is necessary to irrigate a crop in this country, there must be further experiment and careful consideration and comparison of

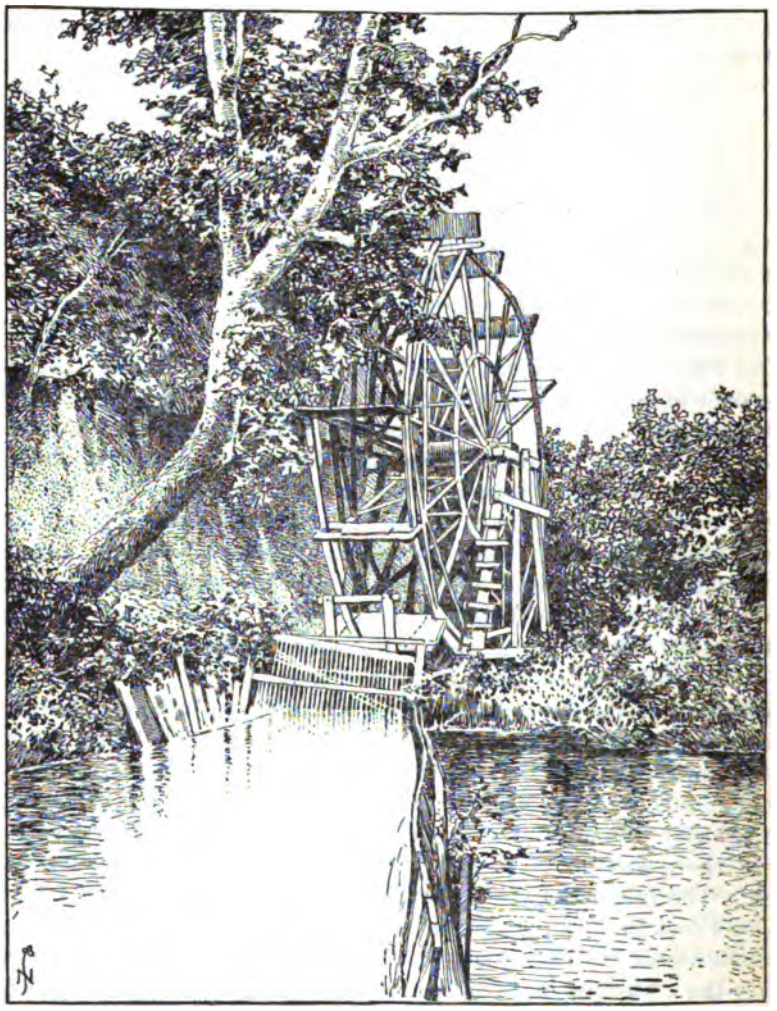


FIG. 4.—Water wheel and wing dam turning current against wheel.

soil and subsoil, percolation, evaporation, and the best method of applying the water to the crop. The duty at Menardville is, under the present system, 44 acres per cubic foot of flow per second, or a trifle under 1¼ inches per acre.

At San Marcos is found a system of water wheels for raising water for irrigation. They are all of the same type, consisting of an under-

PORTION OF WATER WHEEL, SHOWING BUCKETS RAISING WATER.

shot wheel of a size varying according to the height of the river bank. The wheel is run by the direct current of the river, which is quite swift, and is brought against the wheel either by a wing dam of planks, which turns the current against it, or by a ditch taken out about 50 or 100 yards above. The river, coming from immense springs which burst out about three-quarters of a mile above the town, as shown on Pl. I, is not subject to rises, the only flood on record having occurred when a flood in the Guadalupe backed up the water of the San Marcos for eight hours. This renders secure this seemingly unsafe way of locating a wheel. There are three of these wheels on the river, all used by truck gardeners. The wheels are of wood and are the simplest form of undershot wheels, with a metal bucket fastened to the perimeter of one side of the wheel, in front of each paddle, as shown in Pl. II and fig. 4. These buckets fill in succession as the wheel turns and empty into a trough above, thus raising the water very nearly to the height of the diameter of the wheel.

The wheel owned by Capt. John Richards (Pl. II) is the oldest and the one on which all of the others are modeled. He states that before he built it he tried a number of pumps, which required too much attention and repairs, and afterwards several kinds of water wheels, with no satisfaction until he finally hit on the present arrangement of his buckets, which has lasted satisfactorily for about ten years. The wheel runs day and night, and needs no attention save oiling twice a week. It is 20 feet in diameter and 8 feet wide, and is supplied with water by a ditch 150 yards long, taken directly from the river and running through low ground to the wheel. It pumps into an artificial reservoir of about 50,000 gallons capacity. The average speed is three revolutions per minute, and in that time it raises about 90 gallons, or 0.20 second-foot. The water is used to irrigate 3 acres of grapes and vegetables for the market.

The wheel at D. C. Garrett's place, shown in fig. 4, is larger and carries 16 buckets of 6 gallons capacity, pumping on an average 144 gallons per minute, or 0.32 second-foot. He uses no reservoir and irrigates about 12 acres in vegetables.

These wheels furnish a cheap and convenient method of irrigation, being easily built, and running expenses being practically nothing. They are highly successful at San Marcos, but would not be elsewhere where the conditions are not similarly favorable. Here the river has a swift flow and steep banks, from which the wheel may be hung with relatively little expense for scaffolding, and the stream, coming from a great spring, has an even flow summer and winter.

At Austin, the State capital, is one of the largest hydraulic works of the country, impounding water of Colorado River. Although this was built primarily for the purpose of furnishing power, there was at the same time a belief that the surplus water could be used for irrigation above the lowlands along the river at times of summer drought.

This project for thus employing the surplus flow of the stream was abandoned, if not completely destroyed, by the low water of the summer of 1896, when the surface of Lake McDonald was lowered some 5 feet below the crest of the dam. Thus, although there is an immense amount of surplus water carried by the river, it is probable that other works must be built to utilize it, for the steady increase of demands for power tends toward the requirement that the stored water shall be held for this use during the summer months.

The dam at Austin was built by the city with the intention of supplying water for municipal purposes and power for lighting and for manufactures. It is located at a point about 2 miles west of and above the city, where the river flows in a narrow valley between limestone cliffs. At this point the Colorado River drains about 40,000 square miles, and has a usual summer flow of 1,000 second-feet. In times of flood it rises to from 200,000 to 250,000 second-feet, a contingency which necessitated the construction of a strong masonry dam which could be submerged by the highest floods.

The dam is 1,150 feet long, with the crest 60 feet above low-water mark and having a maximum height of 70 feet. It is 66 feet thick at the bottom and 16 feet wide on top, constructed of solid limestone rubble laid in imported Portland cement, faced on each side and on the top with cut granite blocks from the same quarries that furnished the stone for the State capitol. In order to provide for the great volume of water coming down the river in flood times the dam was so designed as to allow the surplus water to flow over it in a sheet of uniform thickness along the entire length. To avoid the impact and erosive action of the falling water, which may sometimes be as much as 15 feet in depth at the crest, the front of the dam was given the shape of a reversed curve of ogee form. This allows the water to glide down its face without shock and expend its force in a horizontal direction against the pool in front of the toe.

There are three iron sluice pipes 36 inches in diameter inserted in the dam, near the west end, for use in possible emergencies. The total cost of the dam, exclusive of the sluice pipes and engineering expenses, was $611,300; the latter amounted to some $58,000 more. The total cost of the whole enterprise, including dam, power house, electric lighting, and waterworks system, was nearly $1,400,000. Lake McDonald, formed by the dam, is over 25 miles long and averages three-fourths of a mile wide. The power available is estimated at about 14,000 horsepower. The power house, shown in Pl. III, is located on the same side of the river as the city and just below the dam. The water is carried directly to the turbines through iron penstocks.

The water for the city is pumped from the lake into the mains, the pumps being directly connected with the turbines operating them. The management is preparing, however, to move these pumps some

AUSTIN DAM AND POWER HOUSE.

distance down the river to beds of gravel forming natural filters, from which perfectly clear water can be obtained at all times. This is the same water as that in Lake McDonald, but it is purified by filtering through these beds. It will be obtained by sinking cribs in the gravel and pumping from them by electrical energy transmitted from the power house. At present the amount of work done varies from 800 to 3,000 horsepower. This is employed for waterworks and electric lighting, and for running all the car lines and most of the manufacturing enterprises in the city, such as planing mills, printing presses, and many others. It has been demonstrated that it is cheaper for a man who uses no more than 200 horsepower to rent his power from the city in the form of electrical energy and to use an electric motor instead of a steam engine.

Up to the present time most of the earnings of the plant have been spent in improving and adding to it; but it is hoped that in the near future these will increase and materially relieve the people of the heavy burden of taxation under which they now labor and enable them to pay off the debt incurred in construction.

Another notable water power which may in the future be partly used for irrigation is that supplied by the Comal Springs at New Braunfels. These springs burst from the base of the hills at many points for a distance of a mile or more and form the head waters of Comal River. New ones can be made at any time by blasting in the limestone rock along the line of those already existing. The fall is so great for the first half mile that no difficulty is found in carrying the water by a simple canal to the point where the accumulated flow can be utilized to good advantage. At present the power is used to operate a cottonseed-oil mill, a flour mill, and an electric-light plant owned by the Landa estate, on whose property the springs are situated. The power used amounts to about 500 horsepower, which can be increased almost indefinitely, if desired.

SAN ANTONIO AND VICINITY.

Under this head is included a description of irrigation works at San Antonio, and also in the areas southerly and southeasterly near San Antonio and Guadelupe rivers down to the Gulf coast. The irrigation ditches at San Antonio are historically the most interesting in the State, for here are found the earliest systems and structures, which have been in use for more than a century. Additional interest is derived from the association of the ditches with the early missions and with the efforts of the Franciscan fathers to settle the Indians upon these lands and employ them in agriculture. The old missions, now in ruins, were rendered habitable by these ditches, and the lands adjacent were the garden spot of the frontier, making possible the growth of the city which now is the center of civilization and trade of the Southwest. These ditches are now almost completely concealed

by the ancient trees and the luxuriant verdure that line the banks, and through the lapse of time they have assumed the character of natural drainage channels, so that it is almost impossible to believe that they were artificial works. The facts concerning the origin and present condition of these ditches were obtained mainly from Mr. Z. O.

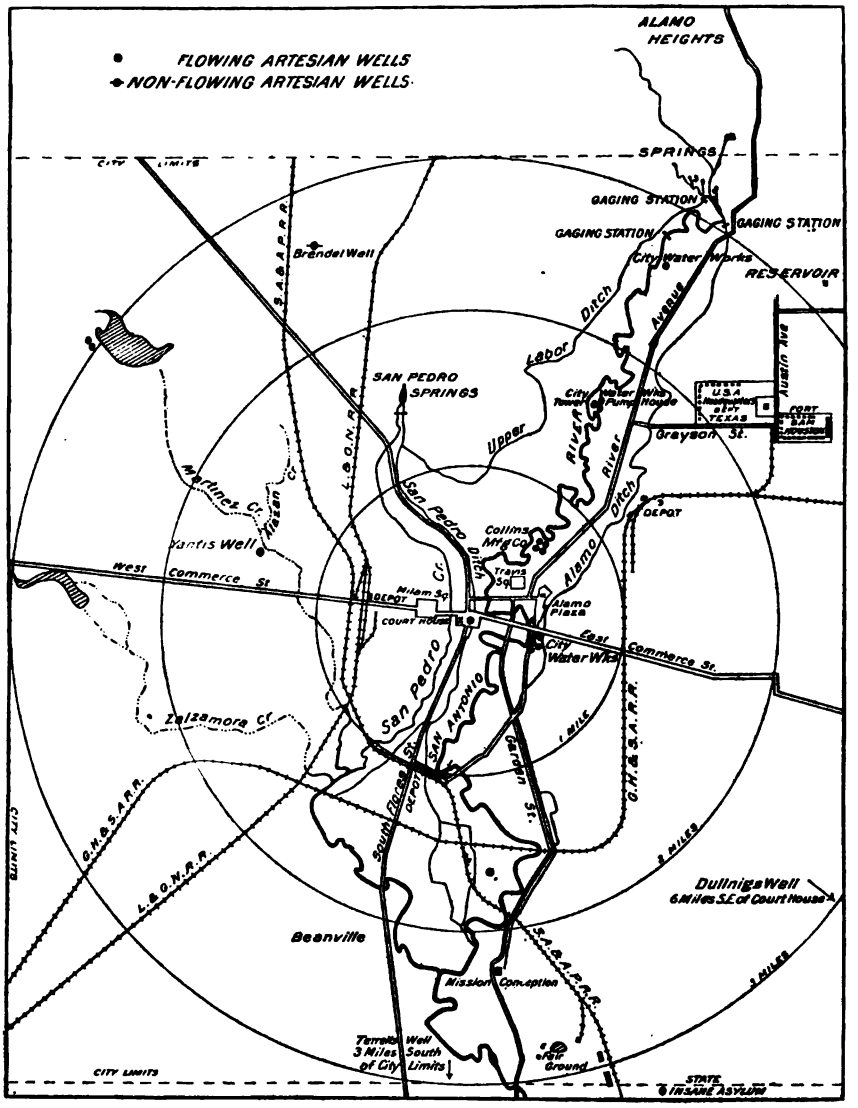


FIG. 5.—Map of ditches and artesian wells at San Antonio.

Stocker, of San Antonio, who has made a thorough study of them, both from an interest in the subject and with a view to developing irrigation enterprises in the vicinity. A view of the river, illustrating its size and character, is given in Pl. IV.

SAN ANTONIO RIVER AT MILL BRIDGE.

The original mission ditches built by the Franciscan fathers between the years 1716 and 1744 are the Pajalache or Conception ditch, the Alamo Madre, the San Jose, the San Juan, and the Espada ditches, all dug to supply the lands belonging to the respective missions. In addition to these mission ditches there was one, the San Pedro, which supplied water to the Villa Capital de la San Fernando, settled in 1730 by the emigrants from the Canary Islands; and one built much later than any of the others under the superintendence of the governor, Baron Ripperda, for the supply of the citizens of the town, and called the Upper Labor ditch.

Beginning at the head of the San Antonio River, as shown on fig. 5, this last-named and most recent of the Spanish ditches is the first encountered. It was begun in 1776 and was ready for use in 1778, under the general direction of the royal governor, care having been taken that no infringement of the prior rights of the five missions and Canary Island settlers should occur. The work was done by those citizens who desired to enlist themselves for that purpose, each furnishing his own tools and at the completion of the ditch receiving a share of the land commanded by the ditch under royal grant, on the condition that he should aid in keeping the ditch and all its appurtenances clean and in repair, and hold himself, with one horse, arms and ammunition, in readiness at all times to meet the enemies of his king. The lands were divided into lots called "suertes" (suerte meaning luck or chance), each one containing the amount of land that could be irrigated by the ditch during a given space of time, usually a day, but sometimes less. The assignment of suertes was always accomplished by lot. The original grade and side slope of these ditches are unknown, but the latter is quite steep, probably about $\frac{1}{4}$ to 1, or at most $\frac{1}{2}$ to 1, yet on all of them the banks, owing to the character of the soil, have withstood the elements remarkably well. The ditches will be described in the order in which they are met with in descending the river.

The Upper Labor ditch takes its water from one of the large springs at the head of the river by means of a loose-rock dam. The ditch follows the contour of the land on the west side of the river and ends in the San Pedro Creek, and once commanded about 600 acres of land, of which only about 100 acres are now irrigated and used as truck gardens. Water rent is $2 per acre. In 1877 the city replaced the old loose-rock dam by a masonry one and built an extension to the ditch, called the Alazan branch. The latter was abandoned in 1896, because the land irrigated was devoted to residences.

The Alamo Madre ditch, built between 1718 and 1744 to supply water to the Alamo Mission and irrigate its lands, derives water from the river on the east side, at a point just opposite the Labor ditch, by means of a low dam. The ditch then follows the contour of the land and runs through the business part of the city. Its length is 6 miles,

and it irrigated about 900 acres, of which only about 220 are now cultivated.

San Pedro ditch was commenced in 1738, and furnished water to the Villa de la San Fernando, the parish church of which, now

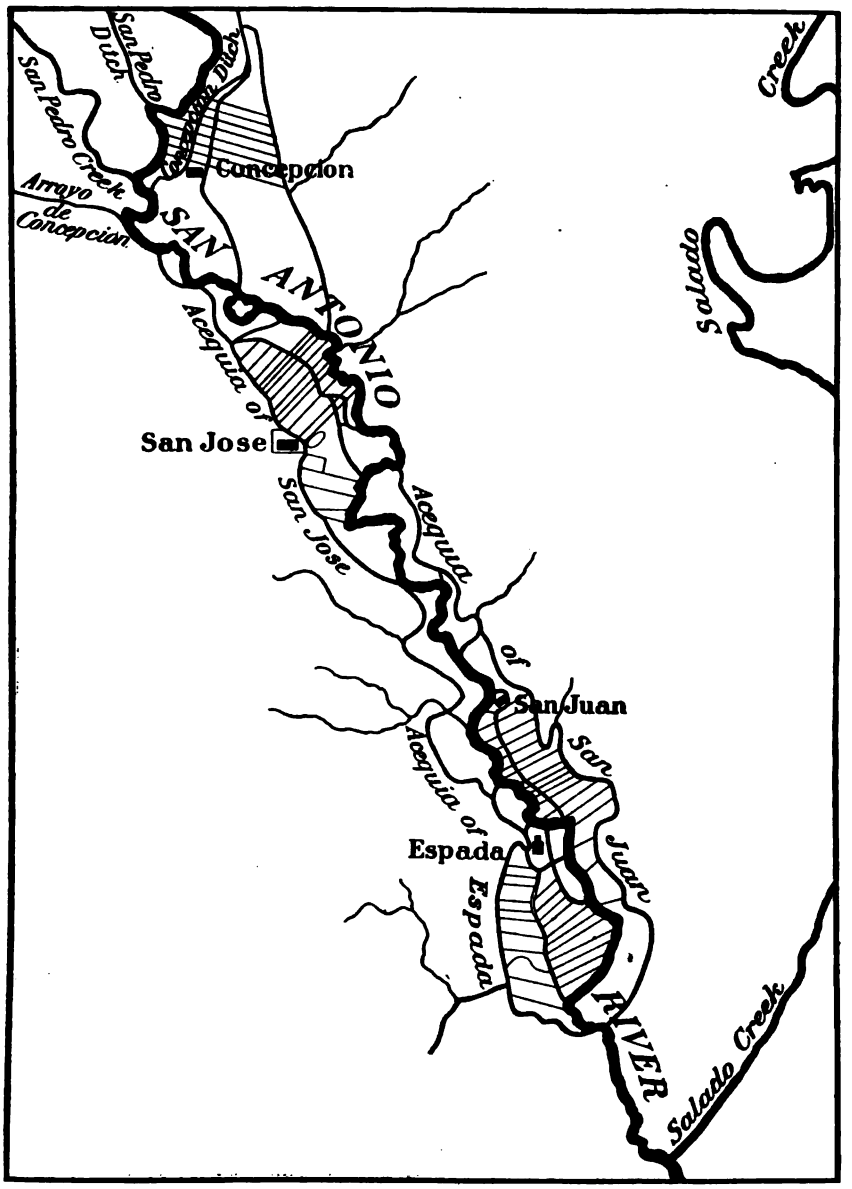


FIG. 6.—Mission ditches below San Antonio.

called the San Fernando Cathedral, is the geographic center of San Antonio. The water for the ditch, taken from the San Pedro Creek, follows down the east side of this and runs through the center

OLD STONE AQUEDUCT CARRYING ESPADA DITCH ACROSS PIEDRAS CREEK.

of the city, irrigating 430 acres of land below town. Its length is about 4 miles and it is 2 feet deep and 6 feet wide. The management of the above-mentioned ditches long since passed out of the hands of the landowners and into those of the city authorities, and is intrusted to a ditch commissioner appointed by the mayor. The annual water rent is $2 per acre. The general location of this and lower ditches is shown in fig. 6.

The next ditch of importance is the Concepcion, built in 1729, and abandoned in 1869 after being in use one hundred and forty years. This was discarded on account of the dam, which was in the center of the city, causing much damage from overflow when there was a rise in the river. This ditch was constructed to furnish water to the Mision de la Concepcion, and was the largest of all the old ditches.

The San Jose ditch was built, probably, about 1720, to supply water and irrigate the lands of the mission of that name, 5 miles below the town. The water was taken from the San Antonio River, on the west side, at a point about 2 miles above the mission, and, following the contour of the land, ran through the mission and returned again to the river about 1 mile below, after irrigating 600 acres. This ditch was abandoned in 1860 on account of the repeated washing away of the loose-rock dam across the river.

The San Juan ditch taps the river on the east side at a point opposite the mission San Jose. It follows the contour of the land and carries its water down to the mission of the same name. It was built in 1731 and is still in use. It irrigates over 500 acres of land, which rent with water for $7.50 an acre per annum.

The Espada is the last ditch taken from the San Antonio River, though one of the earliest in point of construction. It takes its water from the river on the west side at a point 6 miles below the city by means of a loose-rock and brush dam 270 feet long, and built on a natural ledge of rock extending across the river, making the total height of the obstruction 8 feet. This dam consists of layers of brush weighted by loose rock, with gravel and earth thrown in in front, forming a very effective dam, the rock becoming gradually cemented together by a deposit of lime salts from the water. It crosses Piedras Creek on a stone aqueduct, shown in Pl. V, which consists of a series of massive arches that seem in as good preservation to-day as when constructed, more than a century and a half ago. The old Mexican who lived close by asserted that he had seen the water in the creek, in time of flood, flow over the top of the aqueduct, sometimes topping it by as much as 6 feet.

This ditch fell into disuse about twenty years ago and was abandoned until 1895, when A. Y. Walton, jr., who owned several suertes of land, organized the owners of the lands commanded by it into a company (the Espada Ditch Company), cleaned out, widened, and deepened the old ditch, repaired the dam, and made some change in its course, the total cost being about $3,000. The ditch is now 3 miles

long, with a bottom width of 5 feet, and carries 10 second-feet of water. It commands 400 acres, of which 300 are irrigated. The annual cost of keeping the ditch in good working order amounts to 25 cents per acre. The principal crops are 100 acres in corn, 150 acres in cotton, a considerable area in Johnson-grass meadows, and the rest in truck gardens for the city market. The appearance of the crops under these ditches, even in a time of such abundant rainfall as the first half of 1897, is a remarkable proof of the value of irrigation. The land is mostly an alluvial valley soil, very productive when watered. On irrigated fields it is customary to make at least a bale of cotton to the acre, while the average on unirrigated fields for the last five years has hardly been more than one-fourth of that. Truck farmers raise all kinds of vegetables, from early spring until frost, in the greatest profusion.

Three-fourths of a mile above the head of the dam which supplies Espada ditch is the head gate of the Trueheart ditch, the only modern canal taken from the San Antonio River. This was begun in August, 1895, and completed in May, 1896, at a cost of about $18,000; it has a total length of 10 miles and is designed to carry 30 second-feet of water. There is no dam, the canal entering the river directly and the head gates being of wood with brick abutments. The cut for the first 3,000 feet averages 14 feet in depth, with a bottom width of 6 feet. It now carries much less than the registered amount of water, a freshet having washed away the head gates and largely filled up the first few hundred feet of the canal, allowing only about 1.5 second-feet of water to enter it. This is, however, amply sufficient for the land at present under irrigation, which is this year (1897) about 400 or 500 acres, though the canal commands 1,500 acres. The principal crops are alfalfa, Irish potatoes, corn, cotton, and vegetables. The water rights are held at $15 per acre, and the annual rental is $2.50 per acre, but all of the land irrigated so far belongs to the owners of the canal. This canal has seven flumes, one of which, shown in fig. 7, is 1,000 feet in length, with an average height of 20 feet. It carries the water across a valley at Minita ranch, 11 miles from San Antonio. The slope is given as ½ to 1.

There is some irrigation practiced in and near San Antonio from artesian wells, a view of one of which is shown on Pl. VI.[1] The most extensive is that of H. D. Kampman, who has a well on his place with an estimated flow of 1½ million gallons in twenty-four hours under 20 pounds pressure, or 2.32 second-feet. This well is 970 feet deep, and was drilled at a cost of $3,000. It is allowed to flow on 250 acres of the owner's land, this, being in alfalfa, needing only a small portion of the water. It has been stated that this well would irrigate 1,000 acres of land through a system of ditches or storage tanks. A

[1] For details see paper by Robert T. Hill in Part II of Eighteenth Ann. Rept. U. S. Geol. Survey, p. 290.

ARTESIAN WELLS AT CITY WATERWORKS, SAN ANTONIO.

second well near the same place discharges about one-third as much water.

Below the city of San Antonio is an irrigation farm which is probably unique in the State, but which may be considered as being typical of others in various parts of the United States. This is the sewage farm, to which is brought for purification and disposal the waste from the city. This method of disposal is one which is rapidly growing in favor, not only in arid and semiarid regions but in humid countries as well, being extensively practiced in New England and in various European countries. The city sewage farm consists of about 400 acres, subdivided into a number of small tracts or gardens sufficient in area to take all of the present output of sewage. These gardens occupy a space about 400 feet square. Near them are a

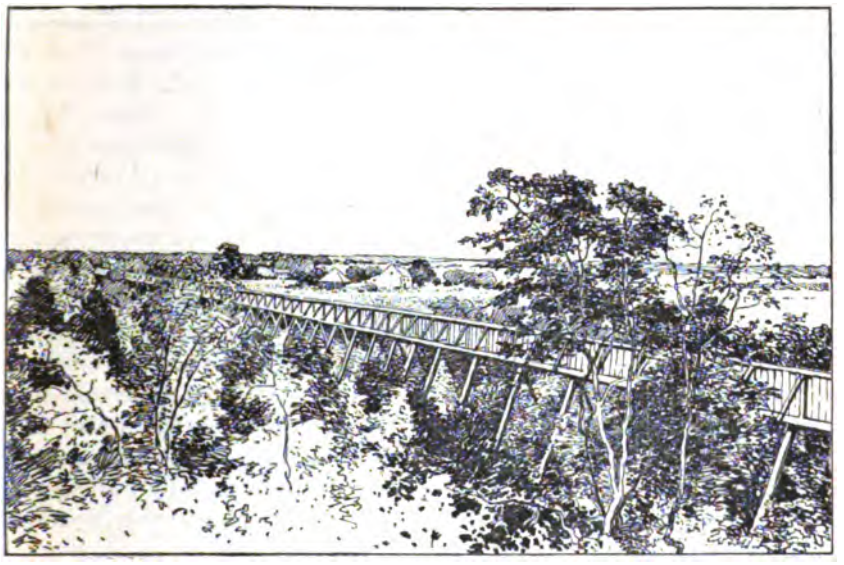


FIG. 7.—View of flume on Trueheart ditch.

number of broad basins surrounded by low dikes to receive the flow from the sewer outlet when water is not wanted on the gardens. It is intended to plant most of these basins in crops which will not be injured by a considerable amount of water, so that the surface will be covered by vegetation throughout the greater part of the summer.

Along San Antonio River below the city are several pumping plants operated by steam. A small one at Elmendorf, owned by C. M. Rounds, is very conveniently arranged for supplying water to a dwelling house and also for irrigating purposes. The water is pumped into an elevated wooden cistern near the river bank and thence piped to another cistern at the house and to the garden and orchard.

Thirty miles below, on the same river, near Floresville, in Wilson County, are reported two more similar plants. That of A. G. Pickett

is the more important. It was set up in 1893 and consists of a 40-horsepower steam boiler, operating a Blakeslee duplex steam pump, which is connected to the boiler by a 2-inch steam pipe. From 12 to 15 horsepower only is used at present, it being the intention of the owner to extend his plant by the addition of more pumps as more land is brought under irrigation. The average distance from the pump to the water is 15 feet, and the average lift is 50 feet. There is no reservoir, the water being pumped directly into the ditch. The total cost of the plant is estimated at $2,500, and it requires one man at a cost of 12½ cents per hour to operate it. The pump is covered by high water in the river from two to four times a year. This plant was built with an idea of irrigating from 300 to 400 acres, and has sufficient boiler capacity, but will require additional pumps. The present pump has a 7-inch suction pipe with a 6-inch discharge, and is estimated to pump about 750 gallons per minute, or 1.67 second-feet. The present capacity is sufficient to irrigate from 75 to 100 acres. The annual cost of water is estimated at from $2 to $6 per acre, according to the amount of rainfall and pumping done. There has been difficulty in getting on the place tenants of sufficient intelligence and progressiveness to use the water on their crops or to grow crops that will repay the cost of water and labor. They prefer to continue planting cotton.

The other plant is located 7 miles from Floresville, and is owned by W. E. Crandall and J. O. Dewees. It was first used in 1896, and consists of a 10-horsepower boiler operating a Blake pump set on the river bank at a distance of 70 feet from the boiler, and with a capacity of from 75 to 100 gallons per minute, or from 0.17 to 0.22 second-foot. The average distance from the pump to the surface of the water is 22 feet and the total lift is 48 feet, the water being pumped into a reservoir 50 feet long, 50 feet wide, and 8 feet deep, formed by building an earthen wall on all sides. The total cost of the plant is estimated at $295, and it is used for raising vegetables.

About 50 miles easterly from Floresville is located the enterprise of the Buchel Power and Irrigation Company. The plant is located 3 miles west of Cuero and is to consist of a permanent stone-and-concrete dam across the Guadalupe River, which, when completed, will be 165 feet long on the crest, or 200 feet long including abutments, 23 feet high, and will raise the water 10 feet above the usual water level. The dam was begun in December, 1896, and in June, 1897, was about one-half completed. The 10-foot head of water will be used to run turbines which will operate force pumps, raising the water a total height of 60 feet to a reservoir about 500 feet distant from the dam. From this reservoir canals will lead to the land to be irrigated. The reservoir is to be an artificial one with earthen banks, and is calculated to have a capacity of 10 million gallons, or 30 acre-feet. The area to be irrigated consists of rich valley land along the east bank of

the Guadalupe River, 2,000 acres of which are owned by the company and will be first put under ditch. If successful with this tract, the company expects to extend the system to cover 2,000 more acres of the same valley. The growth of all varieties of crops is contemplated, but especially alfalfa, fruits, and vegetables. Guadalupe River has an estimated average flow of 800 second-feet, and with the 10-foot head it is expected to develop about 700 horsepower. Probably one-third of this will be used for irrigation, the remainder being converted into electrical energy and carried to the town of Cuero.

South of Cuero about 30 miles, near Goliad, G. W. Simmons has put in a plant consisting of a 2½-horsepower gasoline engine and a pump with a capacity of 33 gallons per minute, or 0.07 second-foot. The water is obtained from a small stream across which has been placed a

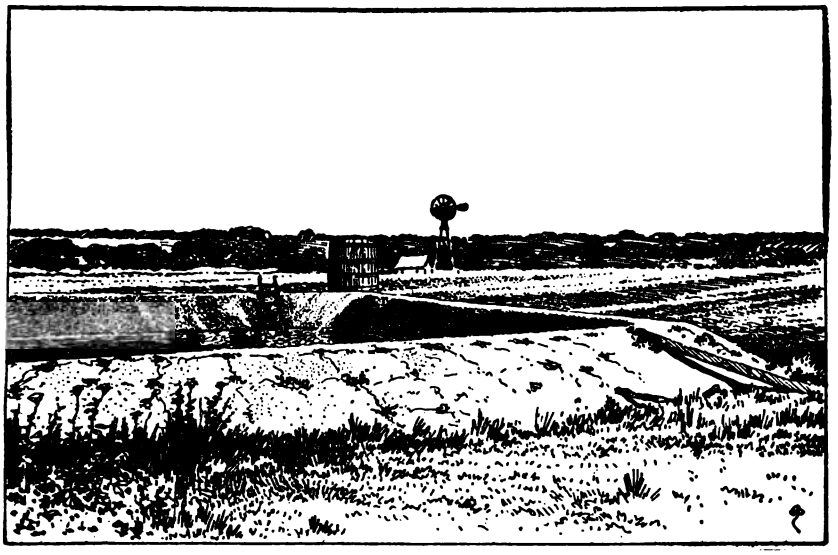


FIG. 8.—View of irrigation tank at Beeville experiment station.

wooden dam 60 feet long and 3 feet high, and is raised 20 feet and pumped directly into the ditch. The total cost was $450, and the plant, while it has not been fully tested, is expected by its owner to irrigate 10 acres.

In Bee County, at the State subexperiment station, under the direction of S. A. McHenry, superintendent, is a pumping plant erected for the purpose of irrigating the orchard and lands devoted to horticultural experiments. It consists of a 5½-horsepower gasoline engine and a windmill, pumping from a well 74 feet deep, in which the water stands 32 feet. The pump has a cylinder 3½ inches in diameter by 36 inches long, with a 24-inch stroke when run by the engine and a 9-inch stroke when the windmill is used. The capacity with the engine is 24 gallons per minute, or 0.05 second-foot. The water is forced 600 feet

to a reservoir at a height of 16 feet above the top of the well. The reservoir is 32 feet long, 52 feet wide, and 8 feet deep, and contains about 100,000 gallons, 0.3 acre-foot. It was built by excavating 4 feet deep and building earthen walls of the same height around it, the total cost being $140. On account of the very porous nature of the soil, all tanks in this region must be lined with some artificial material—cement, asphalt, or coal tar. That at the experiment station (shown in fig. 8, p. 49) is lined with a mastic consisting of 73 per cent sand, 25 per cent coal tar, and 2 per cent lime. The sand and lime are mixed together and the tar is boiled until it will string and is mixed hot with the other ingredients. It is spread on the bottom and sides while hot at the rate of 52 pounds to the square yard. On top is put a varnish formed by boiling pure coal tar and flashing it with a lighted match to burn off the light oils. The plant was completed in 1897 and has been used but little yet. It is estimated that 20 acres can be handled in the present condition of the plant. The engine uses 5 gallons of gasoline in one hour.

On the Kaylor and Heldenfells place, near Beeville, is a circular tank 80 feet in diameter and 12 feet deep in the center. It is lined with cement and supplied with water by two windmills pumping from wells. It commands 40 acres in orchard and vineyard, but has been used very little of late for irrigating and not at all for the grapes. An attempt has been made to subirrigate by means of wooden troughs, but this method has fallen into disuse. In Beeville, W. C. McDowell, since 1893, has been irrigating his truck garden, consisting of one-half acre. Water is raised by a windmill, pumping from a 70-foot well into a wooden cistern of 2,800 gallons capacity.

NUECES RIVER AND LOWER RIO GRANDE.

Nueces River receives the drainage from that portion of southern Texas lying between San Antonio River on the east and the lower Rio Grande on the west. For convenience of description the irrigation projects within this drainage basin are given in geographic order from the head waters to the Gulf, and after these the similar enterprises along the Rio Grande from the mouth of Pecos River southeasterly.

On the head waters of Nueces River, about 4 miles northeast of Leakey, is a brush-and-stone dam across Frio River 45 feet long and 2 feet high, built in 1896. This supplies a ditch 2 miles long, with a top width of 5 feet, bottom width of 3 feet, and depth of 3 feet. It was first used in 1897, and commands 300 acres, of which 115 have been cultivated. Sixty acres are in cotton, 50 in corn, and the remainder in oats and vegetables. Two miles below on the same river is a ditch irrigating 50 acres. Toward the east, on Turtle Creek, in Kerr County, a small amount of land is irrigated, and in Bandera County 300 acres are irrigated by small ditches taking water from Frio River.

At Batesville, and southerly at Carrizo Springs, on the west side of

Nueces River, is a considerable amount of irrigation, or rather a large number of irrigation plants operated by windmills, and at the latter place some irrigation from flowing artesian wells. The appliances are of the usual type, and the acreage commanded by each man is very small, and consequently expensive. In Zavalla County are also 3 miles of ditches and 500 acres under irrigation from artesian sources.

A number of schemes have been proposed for bringing under irrigation considerable areas along Nueces River, especially about the middle portion of its course. The success attained by the present methods, though crude, has been such as to encourage others to attempt the construction of better devices. Actual work has been held back to a considerable extent by the defective laws, but since the passage of more favorable legislation in 1895 several projects have been revived.

Nueces River, with its tributaries, has a catchment area of about 20,000 square miles. The amount and distribution of rainfall throughout this territory is such that, with the sandy soil, a comparatively small amount flows, even in the main stream. Few of the tributaries can be said to be perennial in flow, many becoming nearly or completely dry at certain seasons of the year. The Nueces itself and several of its tributaries, such as the Frio and Lena, head in large springs on the edge of the plateau. Here are admirable localities for diverting water for irrigation. On leaving the plateau country the streams tend to diminish, a considerable portion of the water being lost in the sandy channels, occasionally reappearing when forced to the surface by impervious strata. Throughout the area to the south of the line of the Southern Pacific Railroad the perennial flow is so small or uncertain that irrigation on a large scale must depend upon storage reservoirs holding storm waters.

By consulting a map it will be seen that Nueces River flows from its head in a general southerly direction, but at a point about 35 miles west of Cotulla it turns toward the east. At this point the wagon road between Cotulla and Carrizo Springs crosses by means of a bridge. The region west of the river contains a number of long, deep, narrow bodies of water, known as Soldier, Espantosa, and Caimanche lakes. The two former are practically parallel to the course of the river and are connected by a slough or arroyo, while the northern end of Espantosa Lake is connected in a similar manner with the main channel of the river. In time of flood the water rushes through the connecting channel into Espantosa Lake and returns again to the river, either through an independent channel which issues from the south end of Espantosa Lake direct to the river, or through Soldier Slough or Lake, which in its turn discharges its water through a channel connecting it with the river. In other words, in time of flood the river splits into two, one portion passing through the main channel

and the other being diverted to the west, passing through the lakes and returning again to the river.

Caimanche Lake is quite different in its nature from the two just mentioned. It lies northwest of the Espantosa about 3 miles, and at an elevation of 15 feet above the latter. This lake gathers the water of a large drainage basin, extending from the Rio Grande divide on the south to many miles beyond the Southern Pacific Railroad on the north, a region containing springs and an easily obtainable supply of artesian water. Its water is discharged through Espantosa Slough into Nueces River, and ordinarily its volume is double that in the main channel of the river itself before its junction with Espantosa Slough. It is proposed to convert Caimanche Lake into a storage reservoir by means of an earthen dam $1\frac{3}{4}$ miles in length and 20 or 25 feet in height. The area of the reservoir at the height of 170 feet

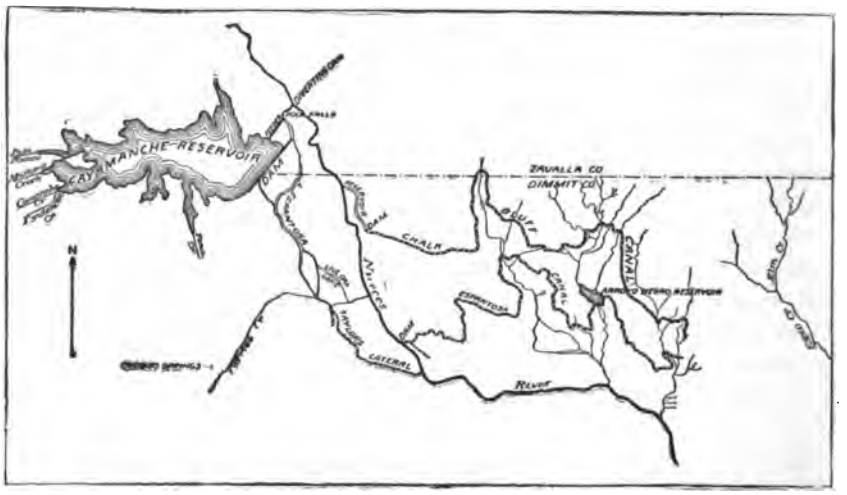


FIG. 9.—Map of the proposed Caimanche reservoir and canals.

above an assumed datum will be 8,500 acres; at 177 feet, or with a dam 20 feet high, it will be 10,000 acres; and at 185 feet it will be 12,500 acres. The original estimates were made for a 20-foot dam, but it has since been concluded that a dam 25 feet high is equally feasible and will make a much greater volume of water available. The spillway will be constructed 5 feet below the crest of the earthwork. Though in possession of no accurate data as to the hydrography of the drainage basin, the projectors are confident that the flood discharges are sufficient to fill the reservoir several times in the course of a year. In addition to the natural drainage of the basin, they expect to avail themselves of the waters of the main stream of the Nueces.

The old channel, connecting the northern extremity of Espantosa Lake with the river, has been already mentioned. Except in flood

seasons, no water enters the lake through this channel, there being a high, rocky barrier in its center, known as Rock Falls. By constructing a diversion dam on the Nueces River below the point where the slough to the Espantosa leaves it, and by cutting a channel 1¾ miles long from the upper side of Rock Falls into Caimanche Lake, the river and the reservoir can be connected.

To use the water so stored it is proposed to pass it down the slough connecting Caimanche and Espantosa lakes, through the Espantosa, and finally into the river channel. From the channel it is to be diverted by means of a dam some distance below the Carrizo Springs bridge into a canal on the east bank of the river. Soldier Slough,

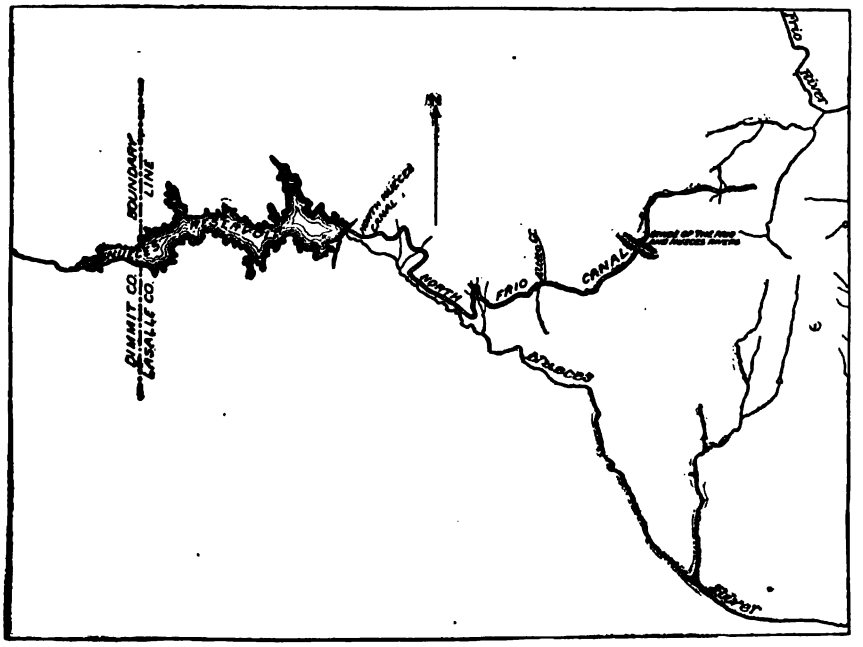


FIG. 10.—Map of proposed Nueces reservoir and canal.

already mentioned, must also be closed by a dam of the same height as the diversion dam on the river. These dams themselves would impound a considerable quantity of water; just how much has not been estimated. At the lower diversion dam the company expect to avail themselves of, first, the water impounded by the dam itself; second, the natural flow of the river; and, third, the storage water of Caimanche Lake. After a diversion line of less than a mile the water of the canal can be taken out on the land. The grade adopted is 1 foot to the mile. The land covered by the canal is among the richest in Texas, well adapted for corn, cotton, sugar, or alfalfa, and the upper-line canal would reach very fine fruit lands. Allowing as much as 2 feet of water per acre per annum, it is estimated

by the promoters that there will be sufficient to irrigate 50,000 acres.

About 35 miles below the diverting dam on the Nueces River turning water into Caimanche Reservoir, the river passes from Dimmit County into Lasalle County, and for about 10 miles below the county line the valley widens, the topography being favorable for the creation of a reservoir. By constructing a masonry dam 2,600 feet long and 50 feet high in the center, it is proposed to create what is known as the Nueces Reservoir, having an area of 12,700 acres. Such a reservoir would receive all of the waste and seepage water from the storage works and irrigation canals above, but, being situated on the main line of the river, would be subject to floods. It is proposed to take out water on the north side of Nueces River by means of a canal, which, winding along the slopes, ultimately passes northeasterly over the divide between the Nueces and Frio rivers, thus commanding a great area of agricultural land. The expense per acre irrigated is estimated to be about double that of the Caimanche project.

About 100 miles farther down Nueces River, at the junction with Frio River, surveys have been made by private capital to ascertain the feasibility of constructing an immense system of storage reservoirs with a view to the irrigation of the valley lands and also that portion of the coastal plain which can easily be reached by high-line canals from the uppermost of the intended works. Fourteen storage reservoirs are proposed for this system, and the sites for these have been examined, located both above and below Live Oak. Their total holding capacity, as stated by William Harrison, who has made all of the surveys, is approximately 1,792,300 acre-feet. Though of so comprehensive a nature, the project can be completed in sections should sufficient water be available, each part becoming a source of revenue possibly years before the final completion of the system. The two most important of the proposed reservoirs will be those formed by permanent masonry dams across the Nueces and Frio rivers, respectively, at what are probably the outlets of ancient lakes, through the beds of which the rivers flow.

The total area which it is estimated may be brought under irrigation by the system of canals supplied by these reservoirs, if filled, is something over a million acres. The soils are principally of three general characters, known under the local names of black mesquite, sandy loam, and resaca lands. The black mesquite comprises most of the coastal slope and valley lands of this region. It is a dark, sandy loam of great depth and richness, easily cultivated, and capable of producing a considerable range of crops. The sandy loam proper is found in the live-oak lands, and is also fertile, though not so well adapted to a variety of crops as the black-mesquite soils. The resaca lands are dark and waxy, being composed of river silt, and possess the fertility always found in such soils. They have been but

little cultivated as yet, owing to their liability to overflow. This latter fault could be remedied by the building of storage reservoirs, which would largely control the flood waters.

Farther down the river is the pumping plant of the Grover Irrigation Company, the most extensive of its kind in this region. It is located on Nueces River, 8 miles north of Mathis, and consists of a 100-horsepower boiler and a 75-horsepower engine, operating, by means of a belt, as shown in fig. 11, a Menge pump with an estimated capacity of from 5,800 to 6,700 gallons per minute, or from 12.92 to 14.92 second-feet. The pump is set in a well 8 feet in diameter, on the banks of the river, and connected with the water in the river by a tunnel 4 feet square. The average lift is 48 feet. There is no res-

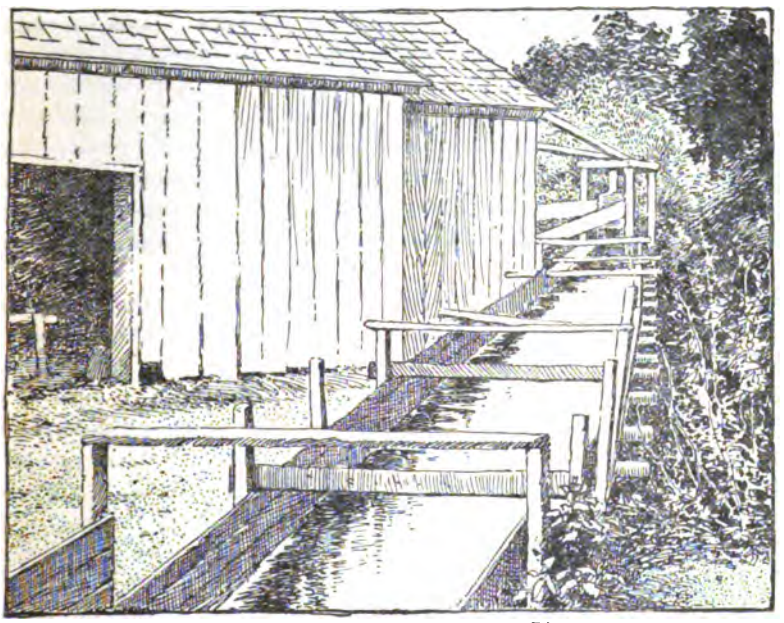


FIG. 11.—Pump and flume on Nueces River.

ervoir, the water being pumped directly into the ditch. The total cost of the plant is given as $5,000, and the running expenses, including engineer at $1 per day, fireman at 75 cents per day, 3 cords of wood at 60 cents, and 70 cents for oil and incidentals, amounts to $4.25. The manager states that he has watered 10 acres in twelve hours on land located near, but never more than half that amount on a tract three-fourths of a mile distant from the pump. This is apparently a low efficiency. The total length of the main ditch is 6,300 feet, with a top width of 6 feet and a bottom width of 2½ feet. It carries about 2 feet of water. This plant has not had a thorough test, as it has never been run steadily. Each individual owner has the use of it alternately for twenty-four hours. It is designed to cover

500 acres, but not more than 70 acres have ever been watered. The principal crops were corn and the vegetables of a truck garden, also a young orchard and vineyard. The corn is irrigated about twice in a season, but in 1897 it was irrigated only once.

Five miles west of Mathis, on the same river, is a pumping plant owned by S. G. Miller and Lon C. Hill, which was built in 1893 and consists of a 40-horsepower boiler connected directly by a steam pipe with a double-action pump having a capacity of over 134 gallons per minute, or 0.29 second-foot, lifting the water a total distance of 39 feet at low stages of the river. The total cost of the plant was about $3,000, and it commands 140 acres in cultivation, of which not more than 70 acres have ever been irrigated. One of the owners states that he has had three years' experience irrigating vegetables, and has not made anything out of it, owing mainly to frosts. Lack of railroad facilities and difficulty of getting goods on the market in good order have been other detriments. He claims that it is a question whether irrigating by steam will pay when raising the ordinary crops of corn and cotton. The continual expense attached to it is too great. Experience has taught him that a man can not irrigate more than 4 acres per day of twelve hours with 1 million gallons, or 3 acre-feet, of water. Ribbon cane has here been found to be the surest and most paying crop tried.

On the Rio Grande below the mouth of Pecos River one of the most important irrigated areas is that along San Felipe Creek near the town of Del Rio. This short creek is formed by four large springs about 1 mile east of the town, within one-fourth of a mile of one another. In the 4½ miles from the springs to the Rio Grande the fall of the stream is 62 feet, thus furnishing an excellent water power for manufacturing. There have been four ditches taken out, two of which are for irrigation. These are supplied with water by means of two permanent masonry dams, 65 and 150 feet in length, respectively, and each 8 feet high. The first-named, shown on Pl. VII, *A*, is nearest the springs and is the starting point of the Madre ditch; the second, about a mile below, supplies the San Felipe ditch, as shown by Pl. VII, *B*.

These systems of water supply were first used in 1879. They are owned by the San Felipe Agricultural, Mechanical and Irrigation Company, in which the shares are held by owners of the land commanded by the ditches. The total cost of the enterprise was about $25,000, and the annual cost of maintaining it is about 50 cents per acre per annum. The main ditches measure about 4 miles in length and are 10 feet wide at the top, have perpendicular sides, and carry about 2 feet of water. The laterals are four in number, with an average width of 4 feet and a total length of 6 miles. The total area irrigated is 3,600 acres, in meadow, cotton, corn, gardens, orchards, and vineyards.

A. DAM SUPPLYING MADRE DITCH AT DEL RIO.

B. DAM FOR SAN FELIPE DITCH AT DEL RIO.

There are about 3,000 acres of irrigable land unutilized on the east side of San Felipe Creek. The land has mainly what is called an "adobe" soil. It is fertile when watered and seems peculiarly adapted to the grape and the pear. All kinds of fruits and vegetables are grown in profusion. On June 15 melons, plums, and apples were ripe. The impression made on the traveler who comes from the droughty and sun-scorched plains to such a spot is not soon forgotten. This cultivated tract has been so isolated from the rest of the agricultural world that none of the diseases which so reduce the profits of the grape or fruit grower elsewhere have been introduced as yet. Grapes produce from 6,000 to 10,000 pounds to the acre, and are mostly made into wine, the above yields giving from 10 to 16 barrels of wine.

East of Del Rio an attempt made to use the waters of Pinto Creek has been unsuccessful because the supply failed just at the season when it was needed. Dams for the purpose of storing the flow of the creek for use in the summer are necessary before anything further can be done. On Mud Creek, C. Vivian, by means of a solid masonry dam 100 feet long, irrigates several hundred acres of land.

At Eagle Pass, about 60 miles below Del Rio, there is a promising enterprise for irrigating a considerable area from the Rio Grande. This river, though dry each year near El Paso, has here a minimum flow of not less than 3,000 second-feet, due mainly to its tributaries, the Pecos and Devil rivers, in Texas, and the Concho, in Mexico. The company building the canal is called the Eagle Pass Irrigation and Waterworks Company. It is proposed to take out a canal with a capacity of 200 second-feet at a point on the river 35 miles above Eagle Pass, where a ledge of rock furnishes a natural dam site and opportunity for locating regulating works. From there the canal is brought down for 12 miles along the base of the hills, which here skirt close to the river channel. Two and one-half miles from its beginning it will empty into Pinto Creek, which will be dammed and will form a settling basin for the coarser silt and sand.

The dam across Pinto Creek will contain scouring sluices for the purpose of keeping the channel free from sediment and of letting the flow of the creek pass in time of flood. At the end of 12 miles the canal comes out on the valley to be irrigated. An old lake bed is surrounded by a semicircular line of ridges which abut on the river at the northern and southern ends. A similar line of hills bounds the Mexican side of the valley. Through this valley the river has cut its channel some 40 feet below the surface, leaving two-thirds on the Texas and one-third on the Mexican side. The canal is designed to skirt along this boundary line of ridges to the end of the valley, where it empties into the river after irrigating 20,000 acres. There is a plan to enlarge it at some time in the future and carry it to Eagle Pass to irrigate some 100,000 acres. The total length of the main canal, as it is to be built now, is 28 miles, with an average

bottom width of 25 feet and carrying 3½ feet of water. It was begun in 1888, when 3½ miles were completed, and the work was then temporarily abandoned. There is little rockwork, and the expense will not be excessive. The estimates for the main canal complete are about $133,000. The side slopes are to be 1½ to 1 and the grade 13 inches to the mile. This is expected to give a current sufficient to largely prevent the deposition of silt from the water before it reaches the land. The land is very nearly level, with a descent down the river of 3½ feet to the mile. The soil is a fertile alluvial loam. The company, which owns all of the land to be irrigated, expects to largely reimburse the shareholders by selling farms of from 40 to 100 acres in area. The annual charge for water will be $1.50 per acre.

At Laredo, about 100 miles below Eagle Pass, considerable interest has been manifested in irrigation by means of pumping. One of the largest plants is that owned by Albert Urbahn, which was completed in 1897 and consists of an 80-horsepower boiler, operating a pulsometer with a nominal capacity of 1,000 gallons per minute, or 2.23 second-feet. The steam is conveyed to the pump directly from the boiler by a 4-inch pipe reduced 1½ inches, and the lift is 65 feet. The pump is operated twelve hours each day, having an actual capacity of 500 gallons per minute, or 1.11 second-feet, and is expected to irrigate 125 acres. So far only 50 acres have been watered. The land is planted in grapes, corn, sorghum, alfalfa, and tomatoes. The water is carried to the land in a 12-inch iron pipe, 2,000 feet long, with outlets at intervals, thus avoiding waste by seepage. The intention is to put in a pump which will utilize more or all of the power as soon as the agricultural situation warrants it. Another pumping plant owned by J. S. Taylor, a successful grape grower, is reported as consisting of two 80-horsepower boilers and a pump having a capacity of 1,250 gallons per minute. E. T. Lamphere has a 10-horsepower Weber gasoline engine with a triplex Van Wie pump, raising 300 gallons of water per minute. Attention is given to this about once in six or eight hours, and at one time during the summer, under pressure, the pump was operated continuously four days and nights, stopping only to oil the machinery.

Three miles from Laredo, L. D. Sterneberg has a windmill by which he pumps from the river when there is sufficient wind, irrigating 3 acres, except in the months of October and November. The cost of his outfit was $220. Three miles north of Laredo, C. A. Charleston has had better success with windmill irrigation than anyone else in that section. He uses a 12-foot wheel and pumps from a 30-foot well into a reservoir of 5,000 gallons capacity, irrigating about 5 acres. The total cost of the plant was $425. He finds his present reservoir too small and is building one of 300,000 gallons, or 0.92 acre-foot, capacity.

At Hidalgo, down toward the mouth of the Rio Grande, is a steam-

pumping plant owned by Closner & Lipscomb. It consists of a 25-horsepower engine operating a centrifugal pump with a capacity of 4,750 gallons per minute, or 10.58 second-feet. The water is pumped from the Rio Grande and is used for irrigating 100 acres in sugar cane and corn.

In the vicinity of Brownsville, near the mouth of the Rio Grande, there has been considerable interest shown in irrigation by pumping. The plant of Rabb & Stark, located 6 miles east of Brownsville, on the river, was built in 1891, and consists of a 50-horsepower boiler and a 40-horsepower engine operating a Menge pump with a theoretical capacity of 9,000 gallons per minute, or 20 second-feet. The average lift is 18 feet, and the pump is run about twelve hours each day during the irrigation season. There is no reservoir used, the water being pumped directly into the ditches. The estimated cost of the plant is $2,000, and it irrigates 200 acres in sugar cane, cotton, and corn.

George Brulay, of Brownsville, also has a pumping plant worthy of attention. It is located 8 miles below Brownsville, in Cameron County, and was completed and first used in 1896. It consists of two boilers having an aggregate capacity of 100 horsepower and a 45-horsepower Morris centrifugal pump with a maximum pumping capacity of 8,000 gallons per minute, or 17.82 second-feet. The total lift required is 22 feet, and the pump is run about fourteen hours per day when used. It is designed to cover 300 acres, but so far only 200 acres planted in sugar cane have been irrigated.

E. H. Goodrich reports having put in a 10-horsepower Priestman engine on a resaca on his place, 6 miles north of Brownsville, in March, 1897, but has used it very little, owing to the favorable weather and the ditches not being finished. With two 12-foot windmills on the same place he irrigated last year about 35 acres in corn, cotton, and garden truck. He has also irrigated between 15 and 18 acres on his place 3 miles north of Brownsville with a 14-foot windmill, pumping from a well dug on the bank of a resaca. The distance to the water varies from 5 to 12 feet, and the pumps, which are three in number, empty into a flume connecting directly with the ditches. He is confident that he could have accomplished much more with the windmills if he had used a reservoir. The total cost of the last-named plant was $300.

LLANO ESTACADO.

The arid portion of Texas, or that part with an average annual rainfall of less than 20 inches, consists principally of the Llano Estacado and Trans-Pecos regions. These differ so widely in topography and climate that they should be discussed separately. The Llano Estacado has been described as a great plateau having an area of about 36,000 square miles and with an almost perfectly flat surface, which rises gradually toward the northwest. No rivers cross its surface and

at only a few widely scattered localities, and for short distances, is flowing water to be found. The soil is of such character that it readily drinks in the rain which falls upon it. This water, or that part of it which is not soon evaporated, percolates downward and is reached by wells of from 40 to 200 feet in depth. Many of these wells are capable of furnishing a supply almost inexhaustible to ordinary means of pumping. The soil is too dry to be successfully cultivated without irrigation, and this can be practiced, if at all, only by means of water raised by pumps. Pumping is most cheaply accomplished by means of windmills, these being particularly successful owing to the almost constant winds that sweep across the plains.

Windmills have been used for many years to furnish water for stock purposes, and they have been tried successfully on a small scale for irrigation. The settlers of this region have learned to appreciate the value and limitations of devices of this character for raising water. Reservoirs or tanks are almost always used in connection with the mills. These are made by scraping away the surface soil and piling it in a continuous wall, forming banks from 4 to 6 feet high. The sides and bottom are made impervious by turning in a little water at a time and puddling the soil by driving horses or cattle about in it for a day or more. The following instances illustrate the progress within this area:

About the center of the Llano Estacado, in Hale County, T. W. Morrison owns a plant consisting of two aermotor wheels, 8 and 12 feet in diameter, respectively, pumping from wells 50 feet deep, with water at 20 feet below the surface. Each windmill lifts the water 35 feet. One wheel is used for supplying the residence; the other pumps into a reservoir 125 feet long and 100 feet wide and 4 feet deep. This irrigates from 5 to 6 acres, besides furnishing water for the stock. His wheels have been in use since 1891. J. H. Wayland, of the same county, has three aermotors pumping from wells 35 to 60 feet deep into a reservoir 300 feet long, 75 feet wide, and 6 feet deep, and expects to irrigate 25 acres, of which 15 were irrigated in 1896. The total cost of the wells, pumps, wheels, and reservoir was $505. The total cost of the plant, which must include land and fencing, is given as $1,000. Southeasterly from here, at Emma, in Crosby County, J. W. Murray has an 8-foot windmill pumping from a well 174 feet deep, with water at 124 feet. He pumps into barrels, from which he irrigates about 1½ acres. The total cost was $222.

Along the Texas and Pacific Railroad, especially at Midland and Marienfeld, there has been considerable interest taken in this form of irrigation. It is claimed by a man of experience—A. Rawlins—that two 8-foot aermotors, pumping from wells 40 feet deep, with water sufficient to keep a 4-inch pump running into a tank 100 feet square, with a 6-foot bank, will give sufficient water to irrigate 10 acres in fruits and vines the first year, 12 acres the second year, and

15 acres the third. Grain and garden vegetables, which require more water, will cut down the average. Fifteen head of horses will puddle a tank satisfactorily. He is irrigating 10 acres in cotton with two 12-foot aermotors, pumping from wells 125 feet deep into a tank 65 feet square.

This region is so sparsely settled and accessible with such difficulty that it has not been practicable to obtain full information concerning the small irrigating plants scattered here and there. Sufficient has been learned, however, to justify the belief that this method of agriculture is becoming a more and more important factor in the development of this area, reducing the cost of supplies, and thus aiding in the main industry, that of cattle raising.

Willard D. Johnson, hydrographer of the United States Geological Survey, states that at not more than half a dozen places in the Panhandle, probably, is there irrigation, from a single plant, of more than a small garden patch, and that of these but two show any development worth mentioning. These two are headquarter ranches of large cattle companies. At the majority of such cattle-ranch headquarters, however, there is absolute barrenness. The exceptions are the "L. E." ranch, on Romero Creek, a small spring-fed tributary of the Canadian from the north, and a ranch on Adobe Wall Creek, another spring-fed tributary of the Canadian from the north. As a result of irrigation, practically from springs, these two large ranches are able to supply themselves with a variety of vegetables and fruits, and in addition grow several hundred acres of alfalfa and other forage crops.

At the "L. E." ranch the garden produces much more abundantly than is demanded for the needs of the ranch, and much of this extra produce is given away to neighbors. The fruit trees which bear successfully are the apple, pear, peach, apricot, nectarine, plum, and cherry. Of shade trees about the house there are locust, ash, willow, osage orange, and cottonwood. There is also a vineyard yielding several varieties of excellent grapes. This ranch was visited by Mr. Johnson. The other ranch, not visited, is reported to have more alfalfa and about an equal display of garden produce. Each of these ranches is located below the edge of the plains, in the little valley of a spring creek of which it uses all the water. More can be done in each case by storage, which, in fact, is contemplated in the case of the "L. E." ranch. The great "X. I. T." company does a little in irrigation at several of its headquarter ranches, but much less than might easily be accomplished.

The two garden spots referred to are notable object lessons to the whole of the Panhandle. Spring creeks in the region are not numerous, but only in these two cases have they been fully utilized, and the examples thus set are destined to be rapidly imitated.

Of the future of irrigation here in general, it may be said that there is opportunity for but the little indicated, at these widely scattered

spots, but that this little will prove to be just that small amount needed for rendering practicable the utilization of the high plains for stock raising, under conditions that will be bearable for those who have to live upon these great pasture lands for the conduct of the stock industry.

PECOS VALLEY.

Pecos River rises in the northeastern portion of New Mexico and flows in a general southerly course through the southeastern part of that Territory, crossing the western prolongation of Texas and finally entering the Rio Grande at about the lower third of the length of that

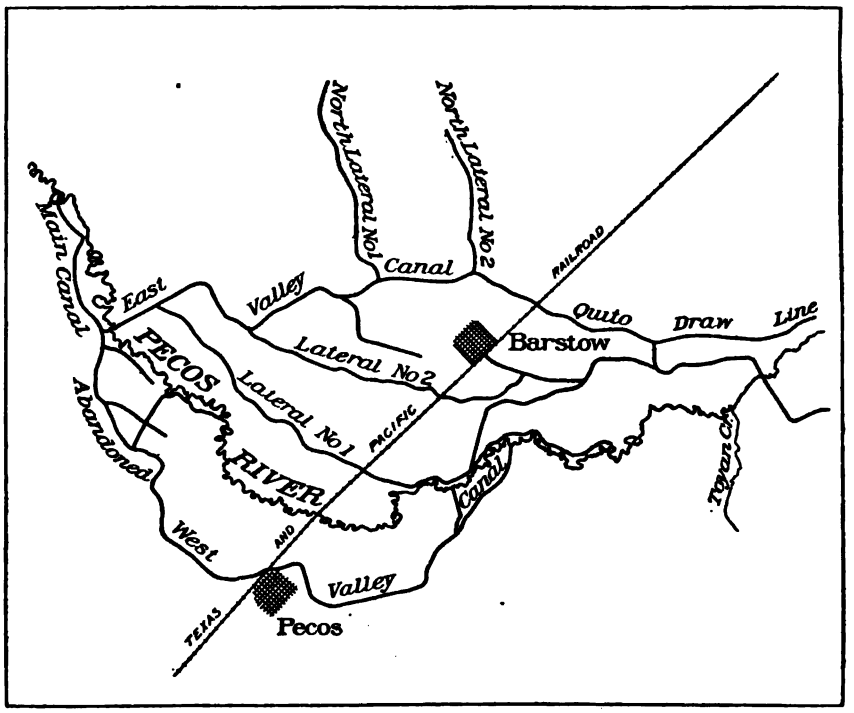


FIG. 12.—Map showing location of Margueretta Canal.

stream. It is supplied to a considerable extent by water from large springs which issue from the limestone rocks of the region, of which Roswell is now the principal town. These maintain the perennial flow of the river, the run-off from the catchment basin being irregular in character and shrinking at times to relatively small amounts. Large irrigation works have been constructed in the vicinity of Roswell and at points below, utilizing the greater part of the summer flow of the river, so that during the dry season of the year little water crosses the Texas line. That which does flow in the stream is largely derived from the seepage of irrigated lands above and is heavily charged with alkaline salts. Irrigation canals have, however, been constructed

FLUME ACROSS PECOS RIVER.

along the valley in Texas, principally near the town of Pecos, at the crossing of the Texas and Pacific Railroad. The valley is fertile, and where properly irrigated large crops are produced.

The most important irrigation system along the river in Texas is the one nearest the New Mexico line, known as the Margueretta Canal. This was begun in 1887 by the Pioneer Canal Company, afterwards consolidated with the Margueretta Canal Company, which now owns the whole system. Water is diverted by means of a brush dam, it being deemed impracticable to build a masonry structure in the sandy river bid. The dam is 90 feet long and 5 feet high. The canal is built, as shown in fig. 12, on the western side of the river for 3 miles, then crosses the stream on a flume (shown in Pl. VIII), and runs in a general easterly direction for 12 miles. There is also a branch continuing down the west bank for a considerable distance, being the main part of the old Pioneer Canal; but this has been abandoned, there being no farms in cultivation for more than a mile or so below the flume. The dimensions of the main ditch are: top width, 30 feet; bottom width, 18 feet; depth of water, 4½ feet. There are three principal laterals, with a bottom width of 12, 6, and 8 feet, respectively.

The canal was first used in 1889, and the extent of land irrigated by it is steadily increasing. The total cost of the system was over $150,000, and the acreage it is designed to cover is about 40,000, only 6,000 of which are as yet under cultivation. The water rights are sold at $10 per acre, a permanent right guaranteeing 25 inches of water to the acre. The annual rental is $1 and $1.50 for each acre served with water. The principal crop is cotton, of which there are about 3,500 acres. The other crops cultivated are alfalfa, sugar beets, and all kinds of forage plants, fruits, and vegetables.

Sugar beets tested in 1896 showed between 14 and 20 per cent of saccharine matter. Peaches, apples, and grapes do well. Cotton averages 500 pounds of lint to the acre. The annual rainfall is about 12 inches. Owing to the high elevation (2,700 feet) the seasons are much later than in most of the irrigated parts of the State. The enterprise seems to have been conducted with energy and care, the canals and head gates are well planned and well built, and all together the scene about Barstow, the center of the irrigated portion, has a general air of healthy growth and prosperity that is very pleasing to the eye after the many miles of desert scenery between it and El Paso. There are, however, a number of problems that must be solved before agriculture will be successful in all places. Much of the land is impregnated with what is known as alkali. At first this does not prove troublesome, but after a few years of cultivation it may be brought to the surface by injudicious treatment. The river water used in irrigation continually adds to the supply of this mineral matter. The only remedy so far applied is drainage, this being as important in its way as irrigation. The land is very nearly level, and considerable

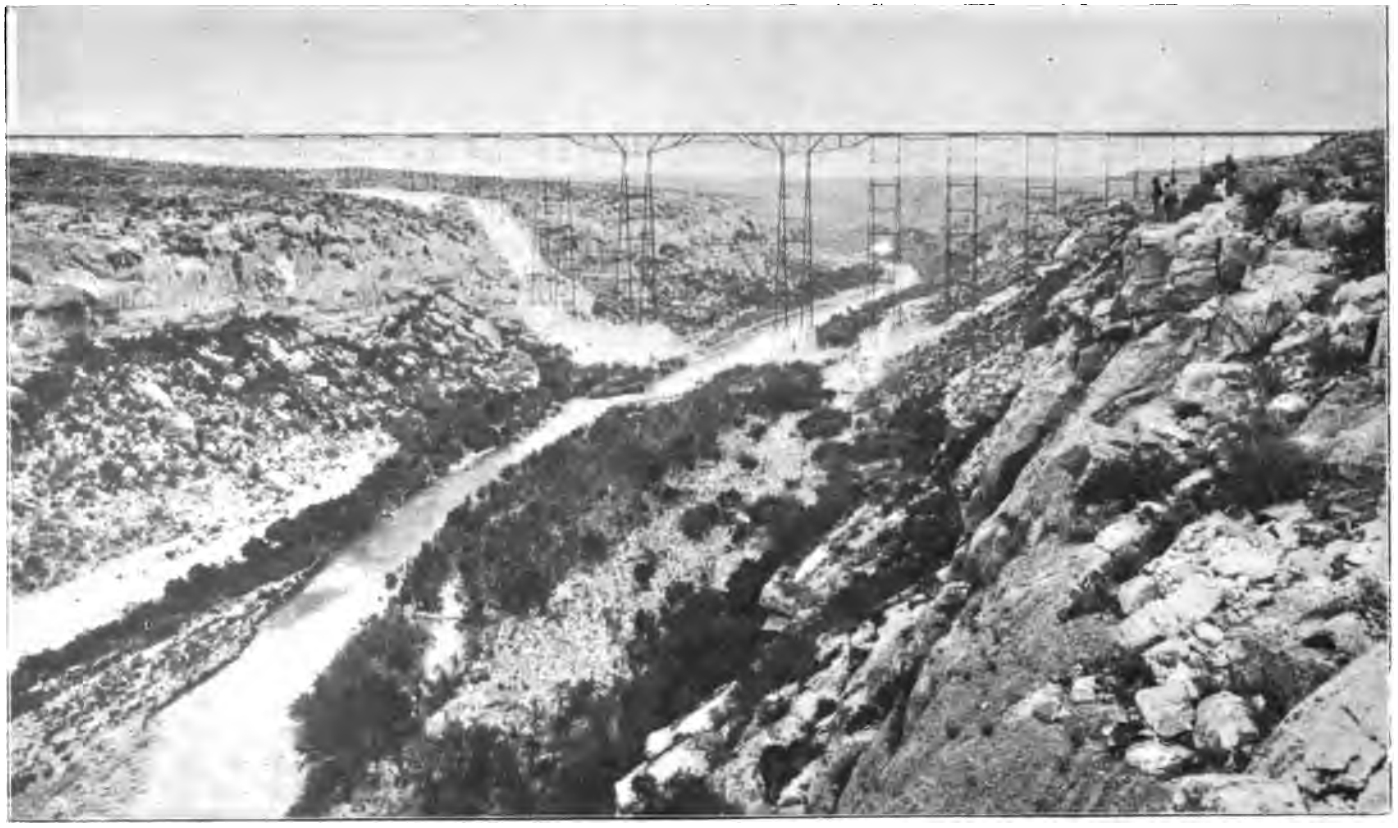
care will be required to provide means by which the accumulated alkali can be washed from the soil. One of the principal crops is alfalfa, which sells at $8 per ton on the cars at Pecos and at $10 per ton retail.

Flowing wells have been obtained in this valley near the town of Pecos. Most of this water contains mineral matter in solution, sulphur being especially noticeable. The water from the wells is used for domestic purposes and also for irrigating kitchen gardens and fruit and shade trees.

About 28 miles below Pecos is the canal of the Pecos River Irrigation Company, on the west side of the river, running in a general southeasterly direction for 12 miles. It is the oldest ditch on the river in Texas, having been built in 1875 and 1876. It was enlarged in 1889 and used again in 1890, but has never been entirely completed in its enlarged condition. It takes its water by means of a brush-and-stone dam about 60 feet long and 5 to 6 feet high. The total cost of the undertaking is given as about $35,000, and the cost of the water rights as from $2.50 to $5 per acre, with an annual assessment of 50 cents per acre. It is designed to irrigate 20,000 acres, but only 600 were irrigated in 1896. There is complaint that the water supply was very short for several years, especially in 1892, 1893, and 1894, just after the dam at Eddy, New Mexico, was completed. The flow has increased since then, but the river becomes quite low and the water bitter in March and April of each year. On this account it is fortunate that the season is so late here that cotton is not planted before April 15, corn about May 15, and alfalfa in June. The soils and crops raised on them are similar to those at Pecos and Barstow.

The Grand Falls Irrigation and Improvement Company takes out a canal 4 miles below the headgates of the one just discussed, but on the opposite side of the river. It was begun in 1896 and is finished for 16 miles; it is supplied by a brush-and-stone dam across the river, 100 feet long and 7 feet high. The water rights are valued at $15 per acre and the annual assessment is $1.25 per acre.

On Comanche Creek, near Fort Stockton, in Pecos County, are two farms irrigated from ditches. That of the Southwestern Irrigation Company is nearest the head of the creek; it is on the east side, 6 miles in length, with top width of 7 feet, bottom width 6 feet, and depth of water 2½ feet. It is filled by means of a loose-rock dam 20 feet long and 6 feet high. More than 1,000 acres have been cultivated, though only 400 were tilled in 1896. The principal crops were alfalfa and corn. The 200 acres in alfalfa gave an average of 5 tons to the acre, the alfalfa being cut five times. Corn yielded 25 bushels to the acre. The lands are cultivated entirely by the company owning the canal. The only other ditch of importance is that of the Rooney Irrigation Company. It runs on the west side of the creek for a distance of 7 miles, its dimensions being 12 feet wide on top, 8



PECOS CANYON AT SOUTHERN PACIFIC RAILWAY BRIDGE.

feet wide on bottom, and having water 3 feet in depth. It was built in 1875 and commands 1,200 acres, of which 1,000 were irrigated in 1896. The principal crops were corn, wheat, oats, cotton, and alfalfa.

At the lower end of its course Pecos River flows through a narrow canyon, illustrated on Pl. IX, taken from Part II of the Eighteenth Annual Report[1] of this Survey. This shows the new bridge of the Southern Pacific Railroad crossing 10 miles above the Rio Grande.

TRANS-PECOS TEXAS.

That portion of the State west of Pecos River is commonly known as Trans-Pecos Texas. It is a peculiar country, rough and mountainous, with no perennial streams. The storm waters rush out upon the lowlands and are rapidly absorbed in the sandy plains, from which the mountains rise abruptly as isolated peaks or ranges. The soil of these plains is of remarkable fertility and when watered produces abundantly. Irrigation, however, is practicable only by means of storage reservoirs holding the storm waters. Such reservoir sites occur in many places, and several of them have been mapped by the topographers of the Geological Survey.

Trans-Pecos Texas is bounded on the west and south by the Rio Grande, from which water is taken for irrigation mainly in the vicinity of El Paso. There are, however, a few tracks watered by small lost streams, there being in particular about 75 acres irrigated from Lympia Creek.

At El Paso the principal canal is that owned by the El Paso Irrigation Company. It was begun in 1889 and completed in 1891. Later the affairs of the company were put into the hands of a receiver, and the property was bought at receiver's sale by Thomas Worthington, of Manchester, England, the trustee for the bondholders. It begins 1 mile northwest of the town of El Paso and runs in a generally southeastern direction for 30 miles. At the beginning its width is 30 feet, but it gradually diminishes to 15 feet at Fabens, where it returns to the Rio Grande. Water is diverted by a masonry wing dam, extending diagonally up the river for about 300 feet and about half way across, as shown in Pl. X. The original cost was approximately $150,000, and some $70,000 has since been expended for protection from overflows and for repairs. The water rights under the new management have not yet been issued. The yearly water rental is $2 per acre. The canal was designed to cover 30,000 acres; 3,000 were irrigated from it during 1896.

There are three old Mexican ditches taken from the Rio Grande below El Paso on the American side, at Ysleta, Socorro, and San Elizario, irrigating from 1,000 to 1,200 acres each. The total area watered in the county is estimated at 8,000 acres. Irrigation has been practiced

[1] Geology of the Edwards Plateau and Rio Grande Plain, adjacent to Austin and San Antonio, Texas, etc., by Robert T. Hill and T. Wayland Vaughan, Pl. XXV, p. 208.

here probably longer than in any other part of the United States. The old Spanish records say that when this pass of the river was first reached by the exploring party of Coronado, villages of Indians were found on the Mexican side on the site of the present town of Juarez and on the American side at Ysleta and below. These Indians had a system of irrigation of seemingly great antiquity, which has been continued and carried on by the descendants of the aborigines and those of their conquerors continuously for three hundred and fifty years.

During the spring of 1897 the large canal was damaged by the flood that submerged so much of the town of El Paso. This flood reached its height on May 26 and quickly subsided. The banks were badly cut and the canal was completely obliterated in some places. The truck gardens and orchards near the city were flooded and damaged, a layer of mud about 3 inches thick being deposited over the surface. It was noticeable that while most trees withstood the flooding comparatively well, the peach trees were almost uniformly killed. Fortunately for the farmers lower down, a portion of the river cut for itself a fresh channel, curving inward, crossing the canal, and then recrossing it at the last point at which the banks were damaged. In this way they have been supplied with water and are able to save their crops, which otherwise would have been ruined.

WING DAM OF EL PASO IRRIGATION COMPANY; LOOKING UPSTREAM.

INDEX.

	Page.
Acre-foot, definition of term	21
Alamo Madre ditch, irrigation from	43–44
Alldridge, G. W., irrigation plant of	33
Artesian wells, irrigation from	46–47
locations of	27
view of	46
Austin, diagram showing rainfall at	23
hydraulic works at	39–41
view of dam and power house at	40
Baker, J. B., irrigation plant of	33
Batesville, irrigation works near	50–51
Beeville, irrigation plant near	50
Black, W. L., irrigation plant of	33–34
Brackettville, diagram showing rainfall at	23
Brownwood, irrigation near	32–33
Brownsville, irrigation works near	59
Broussard, J. E., irrigation by	26
Brulay, George, pumping plant of	59
Buchel Power and Irrigation Company, irrigation works of	48–49
Caimanche Lake, map showing	52
proposed irrigation from	52–53
Carrizo Springs, irrigation works near	50–51
Catron, F. H., irrigation plant of	26
Central Texas, irrigation works and projects in	28–41
Charleston, C. A., irrigation plant of	58
Climatic and geographic divisions of Texas	24
Concho River, irrigation from	31–32
Colorado River, irrigation from	33
pumping plants on	33
Comal Springs, water power of	41
Concepcion irrigation ditch, account of	45
Connell, J. H., work suggested by	7
Cost of water, table showing	12–13
Crandall and Dewees, pumping plant of	48
Del Rio, irrigation near	56
view of dam at	56
view of San Felipe ditch at	56
Duty of water, definition of	20
Eagle Pass, irrigation at	57
Eagle Pass Irrigation and Waterworks Company, works of	57–58
El Paso, diagram showing rainfall at	23
irrigation works at and near	65–66
El Paso Irrigation Company, view of wing dam of	66
works of	65–66
Espada irrigation ditch, account of	45–46
view showing	44
Expense of irrigation, data showing	12–13, 20–21
Fort Clark, diagram showing rainfall at	23
Fort Davis, diagram showing rainfall at	23
Fort Elliott, diagram showing rainfall at	23
Frio River, irrigation from	50
Galveston, diagram showing rainfall at	23
water supply of	27
Garrett, D. C., water wheel of	38, 39
Geographic and climatic divisions of Texas	24
Glenn, J. J., irrigation plant of	32
Goliad, irrigation near	49
Goodrich, E. H., pumping plant of	59
Grand Falls Irrigation Company, works of	64
Grover Irrigation Company, pumping plant of	55–56
Guadalupe River, irrigation from	48–49
Gulf coast region, irrigation works and projects in	25–28
Hidalgo, irrigation works at	58–59
Hill, R. T., acknowledgments to	7
Hill and Miller, pumping plant of	56
Irrigation, methods of	17
Irrigation works and projects, description of	25–66
Kaylor and Heldenfells, irrigation plant of	50
Lamphere, E. T., pumping plant of	58
Laredo, irrigation at and near	58
Leakey, irrigation works near	50
Lewis, Hugh, irrigation plant of	31
"L. E." ranch, irrigation at	61
Lindsey, J. H., irrigation plant of	33
Llano Estacado, irrigation on	59–62
Lytle Water Company, dam of	31
McGee Irrigation Company, works of	32
McHenry, S. A., State irrigation plant conducted by	49–50
Madre ditch, view of dam supplying	56
Margueretta Canal, irrigation by	63
map showing location of	62
Mathis, pumping plant near	56
Measurement of water, units of	21
Menardville, irrigation at and near	34–38
Metcalfe, C. B., irrigation plant of	31–32
Mexia, irrigation works at	29
Morrison, T. W., irrigation works of	60
Mill Bridge, view of San Antonio River at	42
Miller and Hill, pumping plant of	56
Murray, J. W., irrigation works of	60
Nash, W. H., irrigation plant of	27–28
New Braunfels, water power at	41
Newell, F. H., introduction by	9–16
letter of transmittal by	7
Nueces reservoir, map showing	53
Nueces River, irrigation from	50–56

	Page.
Nueces River, view of flume on	55
Pecos Canyon, view of	64
Pecos River, view of flume across	62
irrigation from	62–65
Pecos River Irrigation Company, works of	64
Pecos Valley, irrigation in	62–65
Pickett, A. G., pumping plant of	47–48
Piedras Creek, view showing	44
Rabb and Stark, pumping plant of	59
Rainfall, distribution of	21–24
Ratler, irrigation at	33
Rice, methods of irrigation of	25–26
Richards, John, water wheel of	38, 39
Rio Grande, irrigation from	57, 59
Rooney Irrigation Company, works of	64–65
Rounds, C. M., pumping plant of	47
Sampson, H., irrigation plant of	27
San Antonio, irrigation at and near	41–50
map showing ditches and wells at and near	42
map showing mission ditches below	44
view of artesian wells at	46
San Antonio River, view of	42
San Felipe Agricultural, Mechanical, and Irrigation Company, works of	56
San Felipe Creek, irrigation from	56
San Felipe ditch, view showing	56
San Jose irrigation ditch, account of	45
San Juan irrigation ditch, account of	45
San Marcos, irrigation at	38–39
San Marcos Spring, view of	9
San Saba River, irrigation from	33–38
pumping plants on	33–34
Simmons, G. W., irrigation plant of	49
Southwestern Irrigation Company, works of	64
State Subexperiment Station, pumping plant at	49–50
Steam pumping plants, description of	47–48
Steam pumps, cost of irrigation by	20–21
Sterneberg, L. D., irrigation plant of	58
Stubenrauch, J. W., irrigation plant of	29
Swinden Pecan Orchard Company, irrigation works of	32–33
Taylor, J. S., pumping plant of	58
Texas, climatic and geographic divisions of	24
map of	22
(central), irrigation in	28–41
(Trans-Pecos), irrigation in	65–66
Trueheart ditch, irrigation from	46
view of flume on	47
Upper Labor ditch, irrigation from	43
Urbahn, Albert, pumping plant of	58
Vaughan Agricultural and Improvement Company, irrigation works of	36–38
Water, duty of	20
units of measurement of	21
Water-supply systems of Texas, table showing cost and capacity of	12–13
Water wheel, view of	38
Water wheel and wing dam turning current against wheel, figure showing	38
Wayland, J. H., irrigation works of	60
Wichita River, map of drainage basin of	30
proposed irrigation in valley of	30–31
Willis, J. D., irrigation plant of	33
Windmills, cost of irrigation by	20
use of	27

O

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas by W. F. Hutson, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.

In press:

14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L., vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Survey is 1,000. This quantity falls far short of the demand, so that it is impossible to supply all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules, or who have furnished data. Requests made for a certain paper and stating a reason for asking for it are granted whenever practicable, but it is impossible to comply with general demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.

CONTENTS.

	Page.
Letter of transmittal	9
Introduction	11
Definitions	11
Suction	14
Upstroke	18
Downstroke	19
Valves	19
Piston and rod	23
Piston speed	25
Discharge	28
Efficiency of pumps	29
Mark pump	30
Frizell pump	43
Van Voorhis pump	54
Cook pump	60
Summary	64
Resistance to rotation offered by various crank-driven pumps	65
Various water lifts	73
Bucket lifts	74
Seaman bucket lift	74
Lifting by animal power	78
Some Indian devices	80
An American device	87

ILLUSTRATIONS.

		Page.
PLATE I.	*A*, view of link-belt water elevator; *B*, view of Boyce water lift.	74
FIG. 1.	Vertical sections of bucket pump	12
2.	Vertical sections of piston and plunger pumps	12
3.	Vertical sections of plunger and double-acting pumps	13
4.	Diagrammatic representation of pump problem	14
5.	Dynamometer diagrams of pump-rod stresses	16
6.	Dynamometer diagrams of pump-rod stresses	17
7.	Dynamometer diagram of pump-rod stresses from an 8-inch pump having large clack valves; piston speed, 40 feet per minute	20
8.	Dynamometer diagram of pump-rod stresses from a 6-inch pump having multiple small valves; piston speed, 40 feet per minute	20
9.	Clack valves	21
10.	Dynamometer diagram of pump-rod stresses, showing late closing of suction valve	23
11.	Diagram illustrating relation between piston speed and pull	26
12.	Dynamometer diagram of pump-rod stresses, showing excessive initial shock due to late closing of discharge valve	27
13.	Dynamometer diagram of pump-rod stresses, showing excessive discharge	29
14.	Vertical section of 8-inch brass cylinder with disk valves	30
15.	Discharge curve of 8-inch Mark pump	31
16.	Varying-efficiency curve of 8-inch Mark pump, showing effect of varying height of lift and speed	31
17.	Variation of efficiency with varying height of lift of 8-inch Mark pump at speed of 15 strokes per minute	32
18.	Vertical section of a brass-lined cylinder of small Mark pump	32
19.	Discharge curve of 4-inch Mark pump	32
20.	Varying-efficiency curves of 4-inch Mark pump, showing effect of varying height of lift and speed	33
21.	Variation of efficiency with varying height of lift of 4-inch Mark pump at speed of 20 strokes per minute	34
22.	Discharge curve for 4-inch Mark pump at a total lift of 38 feet and at various suction lifts	35
23.	Vertical section of piston pump with valve chamber surrounding cylinder	43
24.	Discharge curve of 6-inch Frizell pump	44
25.	Varying-efficiency curves of 6-inch Frizell pump, showing effect of varying height of lift and speed	44
26.	Variation of efficiency with varying height of lift of 6-inch Frizell pump at speed of 20 strokes per minute	45
27.	Vertical section of Frizell cylinder with butterfly valve	48
28.	Discharge curve of 4-inch Frizell pump	48
29.	Varying-efficiency curves of 4-inch Frizell pump, showing effect of varying height of lift and speed	49

Page.

FIG. 30. Variation of efficiency with varying height of lift of 4-inch Frizell pump at speed of 20 strokes per minute 50
31. Efficiency of 4-inch pump used as a force pump 53
32. Vertical section of pump designed for slow speeds and low lifts 54
33. Varying-discharge curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed 55
34. Varying-efficiency curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed 56
35. Variation of efficiency with varying height of lift of Van Voorhis pump at speed of 15 strokes per minute 57
36. Vertical section of Cook cylinder 61
37. Discharge curve for 4-inch Cook deep-well pump 62
38. Varying-efficiency curves of 4-inch Cook pump, showing effect of varying lift and speed 62
39. Diagram of resistance to rotation of crank driving a single-cylinder lift pump 66
40. Dynamometer diagram of actual resistance at various positions of crank 66
41. Method of counterbalancing a windmill pump 67
42. Diagram of resistance to rotation of a shaft carrying two cranks driving a duplex pump 68
43. Diagram of resistance to rotation of a shaft carrying three cranks driving a triplex pump 68
44. Gould triplex power pump 69
45. Gould triplex pump and horsepower combined 70
46. Discharge of Gould 4-inch by 8-inch triplex pump 70
47. Varying-efficiency curves of Gould triplex pump, showing effect of varying speed, and at two different lifts 71
48. Dynamometer diagram of uniformity of resistance afforded by triplex pump 71
49. Vertical section of bucket of water elevator 74
50. Dynamometer diagram of uniformity of resistance afforded by Seaman bucket lift 75
51. Discharge per bucket of Seaman bucket lift at various speeds 75
52. Total discharge of Seaman bucket lift at various speeds 76
53. Efficiency curve of Seaman bucket at lift of 18.8 feet 76
54. Plan and vertical section of Stoney water lift 81
55. End elevation of Stoney water lift 82
56. Whim used with Stoney water lift 83
57. Construction of Boyce water lift 87
58. Construction of Boyce water lift 88

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, January 24, 1898.

SIR: I have the honor to transmit herewith a paper entitled New Tests of Certain Pumps and Water Lifts Used in Irrigation, by Ozni P. Hood, professor of mechanics and engineering at the State Agricultural College, Manhattan, Kansas, and to recommend that it be published in the series of Water-Supply and Irrigation Papers. The facts herein briefly set forth represent a large body of original experimental work by Professor Hood and assistants. begun in the summer of 1896 and but recently brought to a finish.

While the water lifts have had their origin in the needs of irrigation, devices for pumping have not; with them, indeed, there is no special adaptation to irrigation use. Economy of power must be the essence of such adaptation; time is not, for ample time can be taken to secure the full supply. But with existing designs, as, for example, the deep-mine varieties, the aim usually has been rather to attain rapidity of delivery, even at the cost of wasteful expenditure of power. Among appliances for irrigation, pumps, of whatever kind, are but in a trial stage. Their wide use and the extension of irrigation possibilities that would result can come only through adaptations in design especially economical of power. It should not be left to come by gradual evolution through chance suggestions of practice, but should be deliberately brought about by engineers. Professor Hood's experimental determinations of efficiencies and of the little sources of frictional loss have contributed data which will be useful for this purpose.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

NEW TESTS OF CERTAIN PUMPS AND WATER LIFTS USED IN IRRIGATION.

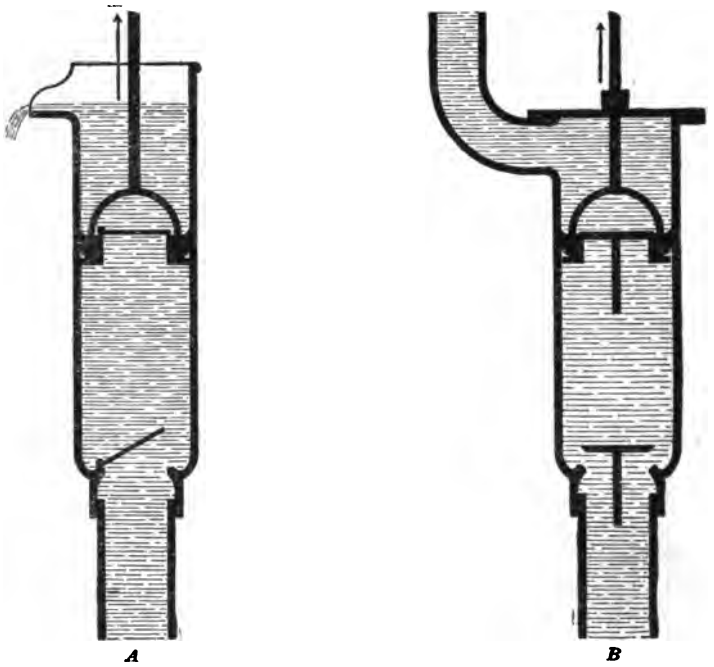
By O. P. Hood.

INTRODUCTION.

The necessity of raising water for irrigation and other purposes has been met by a great variety of water-lifting devices. By far the most familiar of these is the reciprocating pump, ranging in capacity from the simple mechanism for cisterns to the large engines used for public water supply. In order that one may know what it is reasonable to expect from the many forms of pumps, and be able to make an intelligent selection, it is necessary first to become acquainted with some of the problems connected with their design and operation. In this paper it is the author's purpose to state certain of these problems, to give the results of new tests of irrigation pumps and machinery, and to offer notes on several other water lifts in less common use.

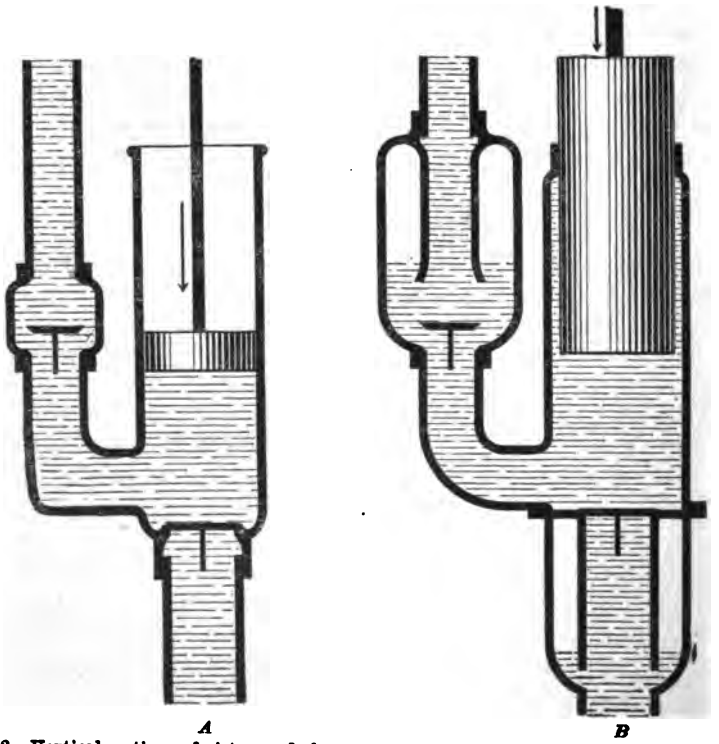
DEFINITIONS.

Of reciprocating pumps there are many forms, and among them there are essential differences. The names commonly used to designate these diverse forms are not in every case self-explanatory; in some cases they may be even misleading. Among these common designations are bucket pump, lift pump, suction pump, combined suction and lift pump, piston pump, plunger pump, and force pump. Common to all these forms is a backward and forward moving piston or plunger. When all the effective work is done while the piston is moving either in one direction or the other the pump is single-acting. When the effective work is distributed between the two motions the pump is double-acting. It is to this alternating movement that the term "reciprocating" applies. Generally speaking, in all reciprocating pumps there are three essential parts—the suction pipe below, the discharge pipe above, and, intermediate in position between these two, the pump cylinder, in which a piston reciprocates.



A B

FIG. 1.—Vertical sections of bucket pump. *A*, ordinary form; *B*, with stuffing box.

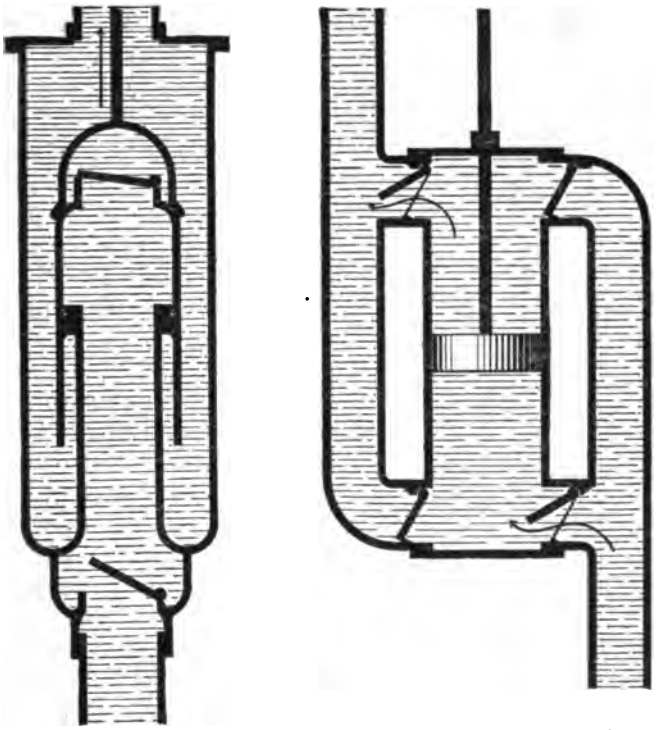


A B

FIG. 2.—Vertical sections of piston and plunger pumps. *A*, piston pump; *B*, plunger pump.

A bucket pump is one in which the reciprocating piston has a valve-covered opening through it. Such a pump is shown diagrammatically in fig. 1, *A*. Between the incoming water and the piston is another valve-covered opening.

If the pump parts are so placed that the suction valve comes below the normal water level, it is called a lift pump. If, on the other hand, the suction lift is relatively great and the delivery pipe short, it is called a suction pump. Most pumps, however, by reason of the more even proportioning of these parts, are called combined suction and



A *B*

FIG. 3.—Vertical sections of plunger and double-acting pumps. *A*, plunger pump with large valve openings; *B*, double-acting pump.

lift pumps. Fig. 1, *B*, shows a pump in which the pump rod is carried through a stuffing box, whereby it is rendered unnecessary for the delivery pipe to follow the pump rod. A piston pump is one in which the piston carries no valve, the discharge valve being otherwise placed, as in fig. 2, *A*. Fig. 2, *B*, shows a plunger pump, a solid plunger, packed on the outside, replacing the piston, which is packed on the inside. Fig. 3, *A*, indicates one of several methods of obtaining large valve openings. Fig. 3, *B*, shows a double-acting pump, serving as a suction and force pump and acting in either direction of movement of the piston. For irrigation the type most in favor is that shown in fig 1, *A*, operated as a simple lift pump.

SUCTION.

Whenever, within a closed vessel, the normal air pressure is by any means diminished, there results what is commonly called suction. Suction is here but a manifestation of superior pressure on the part of the external air. This atmospheric pressure, though varying continually, is, at sea level, about 14.7 pounds per square inch. A column of water about 34 feet in height exerts an equal pressure. Hence, to raise the piston, shown in fig. 4, it is necessary not only to lift the column of water, L, already above the piston, but to overcome as well the atmospheric pressure, equivalent to an additional column of water, B, 34 feet in height; or to overcome, in total, a pressure equivalent to the weight of a column of water, L+B.

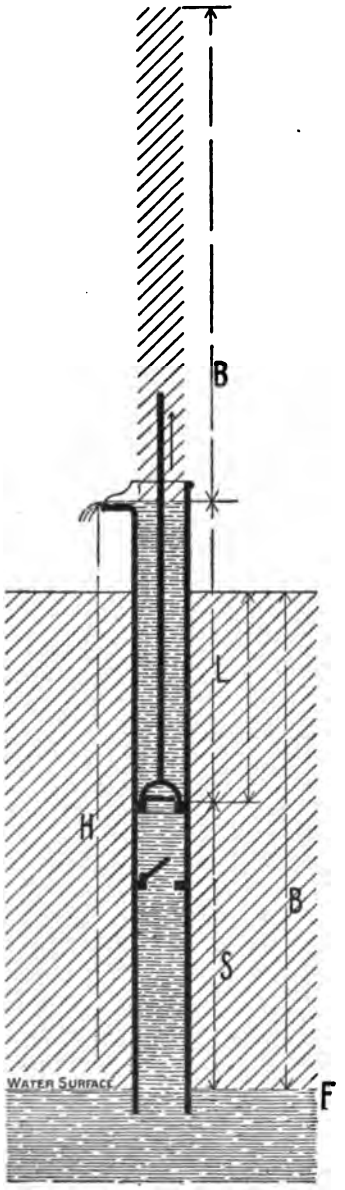


FIG. 4.—Diagrammatic representation of pump problem.

But with the raising of the piston conditions for suction, so called, are thereby at the same time established, i. e., the water surface in the pump tube below the piston is relieved of pressure, whereas outside the tube the atmospheric pressure continues, undisturbed, upon the surrounding water surface. It results that, by reason of this pressure without, water is forced upward in the pump tube; and it continues to follow the piston to a balancing height, which at sea level, as stated, is 34 feet. If the lift of the piston is short of this height the rising water will bear upward against the under side of the piston with a pressure equivalent to the weight of so much of the column as remains, or B—S; less, however, such force as may be used up in overcoming the various resistances during motion. As the piston lift does in fact always stop short of this maximum, the remnant of pressure, B—S, serves as a head of water for effecting flow into the suction pipe and for filling the cylinder. Though the theoretical limit to the height of suction is

about 34 feet, a practical limit is reached at from 25 to 30 feet, depending on the perfection of packing, the tightness of joints, and the piston speed. If, however, the piston speed be too great, the head of water (B—S) may not be able to produce a flow sufficiently rapid to follow it, and in consequence there will be incomplete filling of the cylinder during the period of the upstroke.

The water will encounter resistances to flow in the suction pipe, such as those involved in friction against its sides, in lifting the suction valve, and in passing through the reduced valve opening, all of which resistances will tend to diminish its velocity of entry into the cylinder. The less the height of the suction lift the greater will be the head left for overcoming these resistances, thereby admitting of a more rapid rate of filling and a higher piston speed. Again, by enlarging the suction pipe and thereby reducing the sum of the frictional resistances the flow will be increased. It follows that in practice many pumps have suction pipes of larger diameter than their discharge pipes.

The height of suction lift limits the possible piston speed. To show this, a 4-inch by 14-inch pump was arranged to discharge water at a total height of 38 feet, the cylinder being placed successively at various heights in the pipe, from the natural water level up to the limit of suction. The suction and delivery pipes were each 2 inches in diameter. The various speed limits reached under these varied conditions are shown in fig. 22 (p. 35), in the progressive diminution of discharge due to incomplete filling of the cylinder. The upstroke of the piston may be more rapid than the suction uprise of the water following it, in which case there will be separation of the piston from the following water. This separation may under certain conditions lead to a shock. The separation will begin, if at all, with the beginning of the upstroke; but the acceleration of the upstroke has a diminishing rate, while the speed of the following water may have an increasing rate. If the water overtake the piston about midway of its rise, the meeting will be without perceptible shock; if near the end of its stroke, the shock may be considerable. If, on the other hand, the piston has time to complete the upstroke and accomplish a part of its return, the shock may be severe.

It is these recurring shocks which produce what is called pounding. This action is shown in the accompanying diagrams, figs. 5 to 8, which exhibit the pull on the pump rod at various stages of its stroke. In fig. 5, *A*, the line x, from A to B, represents the length of the stroke, the direction AB the upstroke, the direction BA the downstroke. Vertical distances above the line x represent the pull in the pump rod. Thus, when the piston has reached the point C on the upstroke, the pull in the rod is represented by the line CD, and when it has reached the point E the stress is EF. On the return stroke the stress at E is EG, and at C it is CH. The figures here referred to are

from card diagrams, automatically drawn by a specially devised dynamometer, which was introduced into the pump rod of pumps in operation, so that they record actual practice. The diagram shown in fig. 5, *A*, gives the results of the test of a 4-inch pump having a total lift of 38 feet, a 7-inch suction lift, 2-inch suction and delivery pipes, and a speed of thirty 14-inch strokes per minute, or an average piston speed of 70 feet per minute. The height of the line *ab* shows the pull necessary merely to support the column of water.

At the starting point, A, of the upstroke, the delivery valve closed, and the sudden pull on the rod which resulted is shown by the long vertical line. The depression immediately following is due to the spring of the pump rod and connections upon receiving the first large stress. The upward movement of the water column having become accelerated, a continually lessening pull is required to produce its discharge, as shown by the rapidly falling upper line. The suction valve closes at B, and the weight of piston and rod still produces a small tension in the rod. With excessive friction, or at high speed, this re-

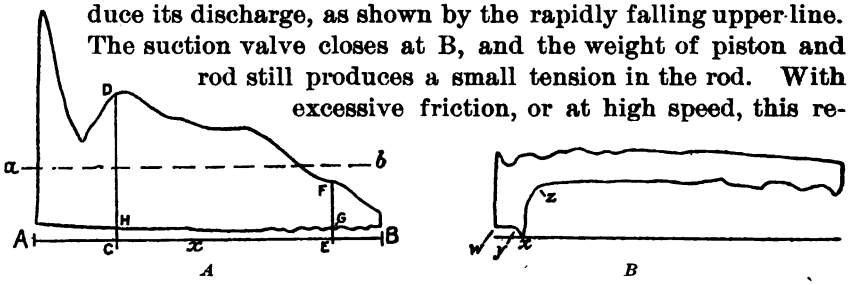


FIG. 5.—Dynamometer diagrams of pump-rod stresses. *A*, general; *B*, with suction lift of 30.8 feet, 30 strokes per minute.

turn-stroke line frequently falls in part below the zero line, showing compression in the pump rod.

In fig. 5, *B*, the pump was given a suction lift of 30.8 feet, with the same total lift and speed, however, as in fig. 5, *A*. The pull on the pump rod is seen to be very differently varied. On the upstroke this pull is much less, having only a small body of water to accelerate in addition to the weight of the atmosphere which it has to lift. The load remains nearly constant throughout the upstroke, the piston not being aided in its upward movement, toward the end, by the momentum of a rising column of water, as in fig. 5, *A*. On the return stroke the downward thrust is aided by the weight of the water in the delivery pipe as well as by the atmospheric pressure, and is resisted only by friction in the cylinder until the piston reaches the point *z*, where it encounters the slowly rising column of water. The blow of the piston against the rising water momentarily relieves the rod of tension, as shown by the drop in the vertical line in the diagram at *x*. This opposing pressure is at once dimished, however, by the opening of the piston valve. At *y* the suction valve closes and remains closed until opened at *w* on the upstroke.

If the piston speed had been slower the cylinder would have more nearly filled, as shown by the card (fig. 6, *A*) taken at 10 strokes

per minute, under which conditions the cylinder had become more than half filled before the shock of meeting. In fig. 6, *B*, the suction lift was 24.7 feet, and at a speed of 30 strokes per minute the cylinder had filled to the point *x*. In fig. 6, *C*, at a speed of 20 strokes, the rising water overtook the more slowly rising piston during the upstroke at the point *z*. In fig. 6, *D*, the speed was but 15 strokes per minute. In this case the following water overtook the piston near the middle of its upstroke, when the difference of speeds was not great, and the diagram in consequence shows at *a* but slightly reduced tension.

It is characteristic of this condition of high suction lift that with the same speed the upstroke of the pump starts more easily than when the cylinder is full, and that pounding may occur at any point in the last three-fourths of the stroke—the nearer its end the more

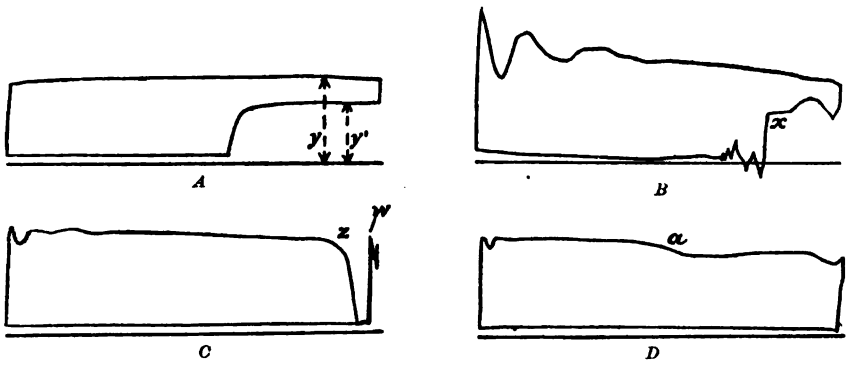


FIG. 6.—Dynamometer diagrams of pump-rod stresses. *A*, suction lift of 30.8 feet, 10 strokes per minute; *B*, suction lift of 24.07 feet, 30 strokes per minute; *C*, suction lift of 24.07 feet, 20 strokes per minute; *D*, suction lift of 24.07 feet, 15 strokes per minute.

severe. A sudden change or reversal of stress in the rod produces disastrous pounding and limits the speed of the pump. It should not be forgotten in this connection that it is weakening of suction head, as it might be called, that is the real cause of pounding, and that the difficulty may arise from undue frictional resistance to flow as well as from excessive suction lift.

It has been a common practice, in order to prevent an intake of sand where the suction pipe is itself the well and not merely a pipe suspended in an open well, to have the whole intake at the foot of the suction pipe through a screen. To the use of the screen there are objections of a serious nature, and the difficulty which is met by its use is best avoided entirely by resorting to the open well. However, if the screen is to be used at all, the total area of its perforations should be at least double the cross-section area of the suction pipe. Even then the screen openings will in time become clogged to such extent as greatly to increase the resistance. Not infrequently in a

pump with a screen intake failure to fill is wholly due to a clogged condition of the screen.

The introduction of elbows in the suction pipe is to be avoided wherever possible. The resistance to flow which they offer is considerable. Again, pipes of the smaller sizes are commonly cut with the rolling cutter, which raises a burr on the inside edge, thereby seriously reducing the entrance diameter. It is worth while to remove this burr. The following table shows the reduced cross-section area of a number of sizes of pipe cut with this tool:

Reduction of cross-section areas of pipes of various size cut with the rolling cutter.

	Diameter of pipe.						
	¼-inch.	⅜-inch.	1-inch.	1¼-inch.	1½-inch.	2-inch.	2½-inch.
Reduced area	*Per cent.* 87	*Per cent.* 77–83	*Per cent.* 88–90	*Per cent.* 80–88	*Per cent.* 85	*Per cent.* 90	*Per cent.* 95

Wherever, as sometimes happens, it becomes necessary to extend the suction pipe horizontally for any distance, such horizontal section should be given a larger diameter than that used in vertical sections. The larger volume of water which the head (B—S, fig. 4, p. 14) must move, together with the added friction of the increased length of pipe and of the necessary turns, reduces the velocity of the incoming water and fixes a lower limit to the possible piston speed.

UPSTROKE.

On the upstroke the pump simultaneously performs two distinct operations: It lifts directly the column of water L (fig. 4, p. 14) and the atmospheric column above it. By thus completely relieving of load the column of water below, it establishes the conditions under which that lower column is driven upward by the atmospheric pressure without. The resistances to upward movement above the delivery valve offered by the water are its hydraulic pressure, its inertia, and its friction. The hydraulic pressure depends on the height H, and is about 0.433 pound per square inch of piston area for each foot of height of water. If the discharge pipe is smaller than the cylinder, the velocity of the discharging water will be correspondingly greater. If the velocity be doubled, the frictional resistances, varying as the velocity squared, will be increased four times. Furthermore, water encounters resistance in making entrance into a pipe; wherefore it is desirable, when practicable, that the discharge pipe should have the same size as the cylinder. If the pump rod be carried through a stuffing box its friction therein will be considerable. There will be frictional loss also at the necessary turns in the delivery pipe, which loss may, however, be minimized by giving to these turns a long radius.

During the upstroke there is acceleration of speed at the outset and

retardation toward the close, the rate of acceleration diminishing toward the center of the stroke, and the rate of retardation increasing from that point toward the close of the stroke. The upward start of the water column is thus, in effect, somewhat abrupt, and in abruptly overcoming the inertia of this water column a pull is exerted upon the pump rod much in excess of that due to the weight of the water alone. This inertia resistance also varies as the velocity squared, and becomes a destructive resistance in fast-running pumps.

DOWNSTROKE.

At the finish of the upstroke the suction valve below closes, and the column of water above it remains at rest until the downstroke has been completed and another upstroke begun. During the descent of the piston through this stationary column of water the piston valve, or delivery valve, as it is called, is opened thereby. The resistances encountered on the downstroke are the frictional resistance of the piston packing and of the column of still water through which the piston has to be forced. It will be apparent that no useful work is accomplished on the downstroke; that all, on the other hand, is accomplished on the upstroke. In rising, the piston lifts B+L, and in turn is pressed upon from below by B—S, the difference between these forces being that force necessary to be applied to the rod and equal to H, fig. 4, p. 14. It is therefore evident that the force to be exerted is measured by the total height of the water lift and is independent of the relation of the suction lift to the direct lift.

VALVES.

There are two common forms of valves—the clack valve, which opens on a hinge, and the disk valve, which rises bodily on guides either at its circumference or along a central spindle. Valves of whatever variety should open and close readily, and should afford, when open, a water way as large and as direct as practicable. To open readily they must not be too heavy; on the other hand, for quick closing weight is an advantage. Also, to give free and large water passage they must have considerable amplitude of movement; yet, again, for quick closing such amplitude of movement is a disadvantage. Thus it appears that of necessity valve design is a matter of compromise among opposing conditions and requirements.

Some of the conditions which bear upon valve design are brought out in the following diagrams. Fig. 7 is the record made by an 8-inch pump having large clack valves, the smallest valve-opening area being 70 per cent of the cylinder cross-section area, and even this is an unusually large valve opening. These valves were in fact so large that, in the experiments, at only 25 strokes per minute they did not close until from 7 to 8 per cent of the stroke had been made. On

the return stroke the lower valve did not close until the piston had had time to travel from B to C (fig. 7), during which time, of course, water was escaping. This delay in closing and the consequent loss of water occurred at the very moderate piston speed of about 40 feet

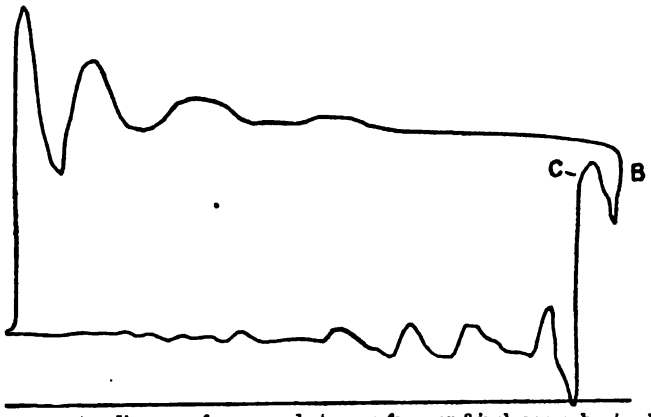


FIG. 7.—Dynamometer diagram of pump-rod stresses from an 8-inch pump having large clack valves. Piston speed, 40 feet per minute.

per minute. Its diagrammatic record exhibits the main defect in large clack valves.

Fig. 8 is the record made by a 6-inch pump using eight small clack valves for delivery valves, having a 14-inch stroke, and operated at a speed of 55 strokes per minute. The aggregate area of the valve openings was 15 per cent in excess of the cylinder cross-section area, yet at this high piston speed of more than 125 feet per minute the delay in the closing of these valves, as shown at A, was very small, being only about 2 per cent of the time interval of the whole stroke. The efficiency of this pump was very high. Thus there is seen to be decided advantage in the substitution, wherever practicable, of several small valve openings for a single large one. Valve lift is thereby minimized and quick closing secured, and without reduction in the aggregate area of valve opening.

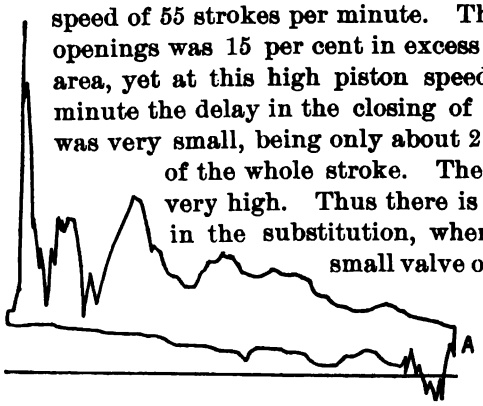


FIG. 8.—Dynamometer diagram of pump-rod stresses from a 6-inch pump having multiple small valves. Piston speed, 40 feet per minute.

That the discharge area around the edge of a clack valve shall equal that of the valve-seat opening, the valve must rise at its outer edge to a height equal to at least half the diameter of the valve opening. The diameter, in inches, of a clack-valve opening should not exceed 100 divided by the speed of the pump in strokes per minute. For example, a pump making 25 strokes per minute should have a clack-valve opening not exceeding in

diameter $\frac{1}{2}\frac{0}{5}\frac{0}{0}$, or 4 inches. Thus the clack valve is limited in use either to small pumps, to pumps of low speed, or to pumps of such design that they admit of the introduction of several small valves in substitution for a single large one.

With multiple valves the valve area should be equal to at least 50 per cent of the cylinder cross-section area. A modification[1] of the usual clack valve is presented in fig. 9, *A*, as an illustration of the manner in which some of the objections to this valve may be overcome. This modification consists in mounting upon the back of the large clack a second clack, covering a valve opening in the first. The tendency of the current of water to open widely the larger clack is in part overcome by the yielding of the smaller clack. It is claimed that higher speeds may thus be attained; also that the modification can readily be introduced into any large single clack already in use.

The advantages of the clack valve are its simplicity and its high efficiency at low speed. Being usually cut out of leather, as shown

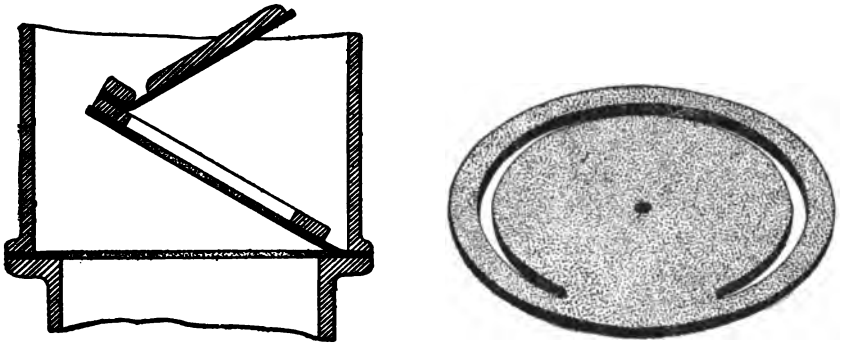


FIG. 9.—Clack valves: *A*, vertical section of double clack valve; *B*, leather suction valve.

in fig. 9, *B*, it is self-packing when closed and is self-hinged. It should be cut from a solid piece of leather, of uniform thickness and without soft spots. The width of the hinge should equal half the valve diameter, and the leather should be placed with the hair side to the seat. A metal disk slightly larger than the valve opening should be attached to the back of the valve, both to add to its stiffness and to give it weight.

Clack valves should have a small angle of lift in pumps running more than 15 strokes per minute. The resistance to flow through clack valves has been determined for the following angular openings:

Resistance to flow through clack valves.

	Degrees of lift.				
	15°	20°	25°	30°	40°
Resistance	*Per ct.* 64	*Per ct.* 53	*Per ct.* 32	*Per ct.* 21	*Per ct.* 10

[1] Barr.

In a 6-inch cylinder, with a 20-foot lift, the piston friction will be about 30 pounds, or 12 per cent of the weight of the water lifted.

The piston friction, regarded thus as a percentage, is, approximately, $\frac{W}{D}$. To show the amount of this piston friction, reference is made to fig. 6, *A*. This diagram is from a pump having a 4-inch cylinder, a 14-inch stroke, and running at 10 strokes per minute. The suction lift was 30.8 feet, and the total lift was 38 feet. There was about 8 feet of water above the piston. The height y represents the pull on the rod due to the lifting of the 8 feet of water, the atmospheric pressure, and the weight of piston and rod, and to the overcoming of the friction of the cup leather.

The piston, once having left the water behind, is beyond the influence of the suction valve. The line y' represents the pull due to the load of nearly 8 feet of water, the atmospheric pressure, and the weight of piston and rod; but it does not represent in this case the friction of the piston, which, on the downstroke, tends rather to reduce the pull on the rod and to produce compression. The difference between y and y', therefore, represents twice the combined piston and water friction in the delivery pipe. At this speed the water friction in a straight pipe is very small, and the difference is almost entirely due to piston friction. In this case it amounts to 30 per cent of y. The piston friction was, therefore, 15 per cent of the whole work done, equivalent to about .18 per cent of the weight of water. The pump leather was three-fourths inch wide. By the above formula $\frac{W}{D}$ would give 18¾ per cent. The width of the packing leather is said to influence the friction very little in heavy hydraulic work, but it seems to be important with the lighter pressures of ordinary pumping.

Piston friction is a large factor in the problem, varying nearly directly as the lift and inversely as the cylinder diameter. The tendency is to render the efficiency of the larger cylinders the higher. Since a single leather has been found insufficient for the prevention of leakage in pumps working in deep wells, two, or sometimes even three, are used. Where these leathers can not readily be procured they can be made by soaking good harness leather until pliable and then bolting it into a wooden form. To make the form, a board about three-fourths inch thick, having in it a hole of the same diameter as the pump cylinder, is nailed to a stiff backboard, and a cylindrical block, three-eighths of an inch less in diameter, is bolted concentrically within the circular opening. The bolts should be long enough so that the wet and pliable leather, laid over the hole, can be drawn down by the bolts and block, forcing the leather into position. The wrinkled edge of the leather can then be trimmed off, and when the whole is dry, removed and brought to a thin and even edge with a sharp knife. The friction of the piston leather should not be so

great that on the downstroke the piston will not return by its weight alone.

Metal rods joined by screw couplings are commonly used in such pumps. By using a large rod a differential action is obtained in the delivery, rendering more uniform the work between the upstroke and the downstroke. A stiff rod is necessary where water is delivered on the downstroke. Wooden rods, because of their elasticity, frequently give less trouble at connections than metal rods, and where delivery pipes are large enough they are sometimes preferred.

PISTON SPEED.

Four factors tend to limit the piston speed: First, the excessive initial shock of lift on the upstroke; second, the tardy closing of valves; third, incomplete filling of the cylinder; fourth, the rapid lowering of general pump efficiency as the speed is increased.

To give to a body of water rapid motion necessitates a greater expenditure of energy than would be necessary simply to balance its static pressure. The acceleration of motion of the water is greatest at the beginning of the upstroke, and, as the rotative speed of the crank increases, the acceleration and the force necessary to produce it also increases. In practice the quantitative importance of this first stress is found to be largely a matter of pump design. If the rod is short and the pump connections and frame very rigid, the stresses will increase to a high limit earlier than when the machine has a certain lack of rigidity. The yielding of windmill towers to the various shocks of pump operation is in those structures a means of keeping down this stress. The extension and the elasticity of the pump rod also tend to soften the shock of starting the water column. The spring of parts is, therefore, in some degree, rather an advantage than otherwise, and the incorporation of a stiff spring into the pump rod would be advantageous.

In some of the pumps tested the pump rod had a length of about 40 feet and the machinery was placed upon an unusually rigid floor. Fig. 11 shows the maximum stress for a number of pumps tested from this floor. The horizontal distances represent average piston speed in feet per minute. With the pump piston at rest, the pump rod supported a certain constant load. With the pump piston in motion, this load no longer remained constant, but varied, being greater at the beginning of the stroke and at the end usually less; and this variation was found to increase as the speed increased. In fig. 11 distances above the base line exhibit this increase of stress. Vertical distances represent the maximum load while running, expressed in percentages of the quiet load. For example, in the test of one 4-inch pump it appeared that at a speed of 40 feet per minute the maximum load on the rod was 175 per cent of the quiet load, while at a speed of 80 feet per minute it was about 200 per cent. In

the test of another 4-inch pump, at these same speeds the corresponding percentages were 200 per cent and 400 per cent. At piston speeds of 70 feet per minute the initial stress may be equivalent to from two and one-half to five times the weight of the water. The percentages are greatest where loads are light. Where the parts are not of ample proportions, or where they are loosely assembled, the shocks due to this initial stress soon destroy the machine.

The stresses shown in fig. 11 may in large part be due to the late closing of valves. In fig. 12, delayed and sudden application of the load after the piston had acquired a high speed, at one-tenth of its upward stroke, produced a much more severe shock than would have

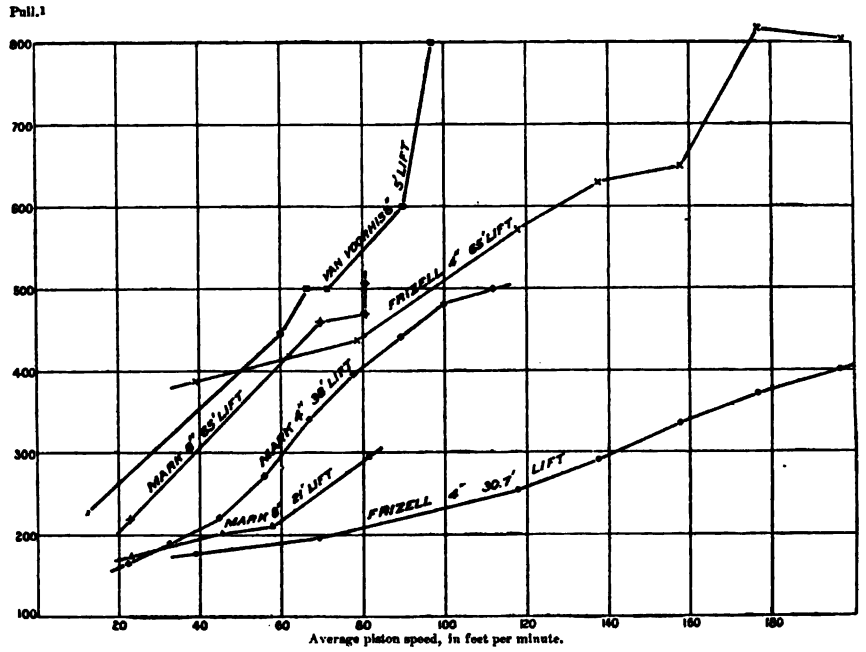


FIG. 11.—Diagram illustrating relation between piston speed and pull.

been felt if the valve had closed earlier. The effect of this slow closing of large valves is shown by the upper line in fig. 11. In the case of the lower valve it produces a blow on the under side of the piston, and frequently the shock of this blow is such as to jar a spray at each stroke from the upper surface of the water in the delivery pipe.

Incomplete filling of the cylinder limits piston speed, as shown in figs. 5, B (p. 16), to 6, D (p. 17). There is no advantage to be gained in running faster than the cylinder can fill. The upward tendency of the water into the cylinder depends rather upon other forces which we have called "head." We have seen that "suction" is the name

[1] Per cent of hydraulic pressure on the piston, representing maximum pull on the pump rod.

for an appearance rather than for an actual fact. The piston merely relieves the lower water column of load, and this column rises really under impulse from other agencies. It becomes the business, then, of the piston to keep the load that had held it down out of its way. Incomplete filling reduces the maximum stress nearly to that of a constant load, and indeed during the first part of the upstroke it results in more quiet running; but on the downstroke, on the other hand, with water and piston moving in opposite directions, it produces serious pounding.

Longer strokes admit of a much more rapid piston speed. This speed is limited by the number of times per minute the valves can open and close without serious shock and by the clear valve area. William Barr, in discussing steam pumps, says of the action of these valves: "The area of clear way through a set of valves in a water end should be not less than 40 per cent of the plunger area for speeds

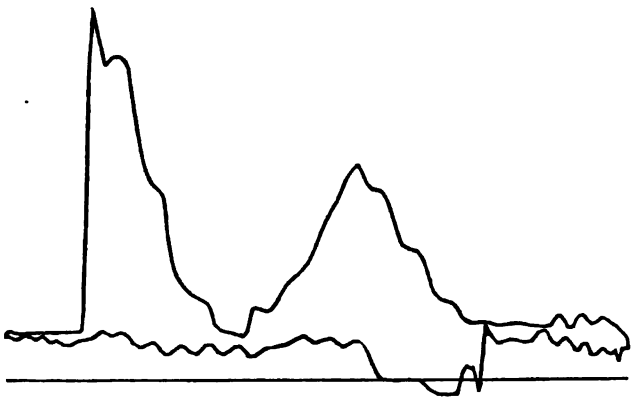


FIG. 12.—Dynamometer diagram of pump-rod stresses, showing excessive initial shock due to late closing of discharge valve.

of 100 feet per minute, 50 per cent for 125 feet, 60 per cent for 150 feet, 75 per cent for 175 feet, and 100 per cent for 200 feet per minute." With the usual windmill speeds, not exceeding 30 strokes per minute, a stroke of 2 feet would give a piston speed of 120 feet per minute, and should be possible with pumps having 50 per cent of clear valve area. Steam pumps, as stated by Barr, have a low efficiency as compared with some of the best forms of irrigation pumps; and while the above speed is possible, the valve area for high efficiency should be larger still. It is impossible accurately to set limits to pump speed, because it depends upon valve design and upon length of stroke, which in turn vary greatly in different forms of pumps.

The individual peculiarities of various makes are well brought out in fig. 11. The 4-inch Frizell pump, which gave the lowest maximum stress, and therefore made record of smooth running, had a valve area of but 27 per cent, while the 8-inch Van Voorhis pump, which

had 97 per cent of valve area and a short stroke, was noisy. In general it may be said of a reciprocating pump that a speed of 100 feet per minute is about all that should be expected. The following table shows the highest piston speed employed in the test of a number of irrigation cylinders. For a regular working speed it would be excessive

Speeds of piston in irrigation cylinders.

No. of fig. herein.	Diameter, in inches.	Stroke, in inches.	Speed, in feet per minute.
18	4	14.00	114
27	4	23.70	198
23	6	14.11	141
14	8	13.95	90
32	8	10.00	216

Weisbach says: "Usually the velocity of the piston is not over 78 feet per minute, the common valve ranging between 40 and 60 feet, though piston velocities of 196 feet sometimes occur." In some high-class pumping engines speeds of 480 feet have been obtained.

While it is possible to run at a high speed, it may not, for practical reasons, be desirable to do so. By referring to the diagrams showing the efficiencies of pumps of various design it is seen that all are more efficient at slow speeds. A fall in efficiency of about 15 per cent—up to 30 strokes per minute—is to be expected, even in a good pump. A large pump run slowly will, therefore, work with small power and to better advantage than a smaller pump at a higher speed. For the very best results in connection with a windmill a higher gearing than the usual 3 to 1 would be advisable, the limiting factor being the increased expense of the larger size of pump thus made necessary.

DISCHARGE.

The discharge of a pump per stroke is measured by the capacity of the cylinder within the stroke length, less, however, the amount by which the cylinder may have failed to fill on the upstroke, and less, as well, those losses on the downstroke which will result from back-slip of water past the tardily closing valve and from leakage through the valve after closing. The discharge of various cylinders tested is given in diagrams accompanying the description of each. Reuleaux gives the discharge, in per cent of the geometrical displacement, as 92 per cent at a speed ranging from 27 to 40 strokes per minute, 95 per cent at 50 strokes, and 98 per cent at 60 strokes. At slow speed the leakage reduces the discharge by an amount ranging from 1 to 5 per cent. This loss diminishes, as a percentage, with increase of speed, but with high speed the loss from slow closing of valves rises and soon outweighs it. Weisbach states the loss to be from 5

to 15 per cent, which seems excessive for such cylinders as have been tested by the writer.

Where the velocity of water is high, owing either to a high piston speed or to a small pipe, the discharge per stroke may even exceed the cylinder capacity per stroke. The momentum of the rising water may be sufficient to hold the valves open for a brief interval after the completion of the upstroke, and thus for a moment to continue intake after the beginning of the downstroke. The paradoxical character of this effect is brought out by the discharge curves in figs. 19 (p. 32) and 22 (p. 35), and by the stress diagram, fig. 13. This stress diagram is a record from the work of the pump shown in fig. 18 (p. 32), and indicates that the tension on the rod in that pump, under the conditions imposed, was relieved by the momentum of the rising column of water before the end of the stroke had been reached, and that this momentum impulse continued effective until the lower valve had closed, at A (fig. 13), on the return stroke. This same effect may be observed when the suction pipe is carried to a considerable horizontal distance, increasing the weight of the moving water. Unless a suction chamber is put on in such cases, the suction pipe should increase in area directly as the length increases. Fig. 19 shows an example of the discharge being increased by a more rigid setting.

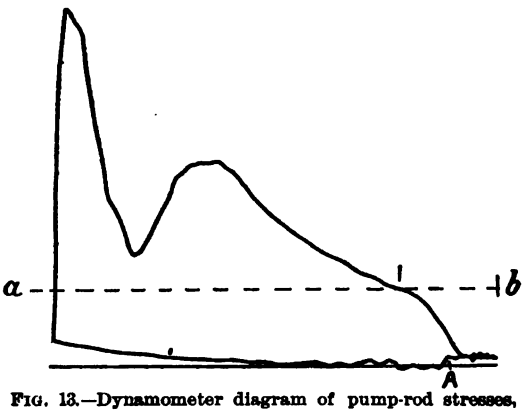


FIG. 13.—Dynamometer diagram of pump-rod stresses, showing excessive discharge.

EFFICIENCY OF PUMPS.

The efficiency of a pump is that percentage of the effort expended which is returned in useful work as water lifted. Efficiency will vary with the design, speed, and adaptation to the particular use. In small steam pumps the useful work done will account for only about 50 per cent of the power developed by the steam. Weisbach states the efficiency to be, "in well-designed pumps, working under favorable conditions, 80 per cent; in pumps of average perfection, 75 per cent; and in ordinary pumps, 70 per cent, and sometimes 65 per cent only." Mr. William O. Weber[1] gives the efficiency of reciprocating pumps as follows:

Efficiency of reciprocating pumps.

Lift (feet)	10	15	20	25	30	35	40	50	60	80	100	120	160	200	240	280
Efficiency	30	45	55	61	66	68	71	75	77	82	85	87	90	89	88	85

[1] Trans. Am. Soc. Mech. Eng., vol 7, p. 598.

To determine the usual range of efficiency for such pumps as are offered for irrigation purposes, and to determine what room there may be in them for improvement, the author has made something more than 1,000 measurements of various designs. The process by which were obtained the stress diagrams previously referred to affords a method for determining the amount of work, useful and otherwise, performed by the pump. By weighing the water discharged at various speeds and lifts a rating curve for each pump was obtained; and the useful work was determined by multiplying the weight of water discharged by the total lift. The diagrams show only the work actually performed by the pump rod, and therefore do not exhibit the ineffectual effort of the mechanism which transmitted power to the rod. The efficiencies are those of the pump cylinder and the pipes alone. They seem to show that some forms of the irrigation pumps tested here compare very favorably with those tested by others. Each pump has a particular sphere to which it is best adapted. No great increase of efficiency over the best now to be had is to be expected in any new form. Many of those now in the market could be much improved. The pumps represented in the drawings are typical, and by noting their performance, as shown in the following diagrams, the general range of efficiency of other pumps may often be closely approximated.

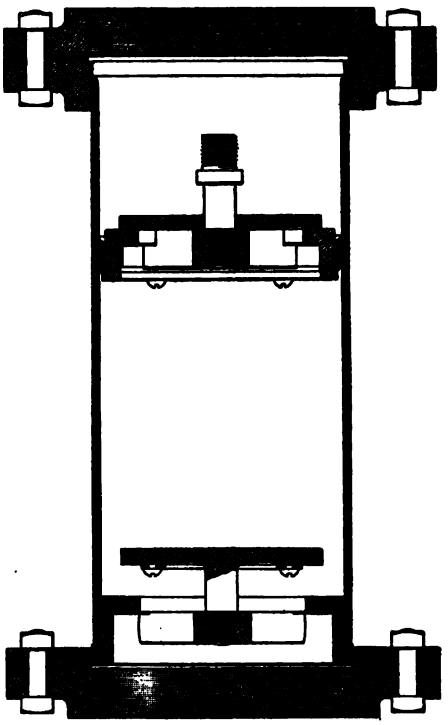


FIG. 14.—Vertical section of 8-inch brass cylinder with disk valves.

The efficiency is seen to rise with increase of lift and to fall with increase of speed. The maximum efficiency is reached at lifts lower than those of Weber's table. Certain pumps may be expected to have an efficiency above 80 per cent at the usual speeds and at moderate lifts. Efficiency with such will but slightly increase, if at all, at lifts of more than 50 feet.

MARK PUMP.

Fig. 14 shows an 8-inch brass cylinder having disk valves with limited movement. It is made by the Mark Manufacturing Company, of Chicago, Illinois, and is specially designed for irrigation work.

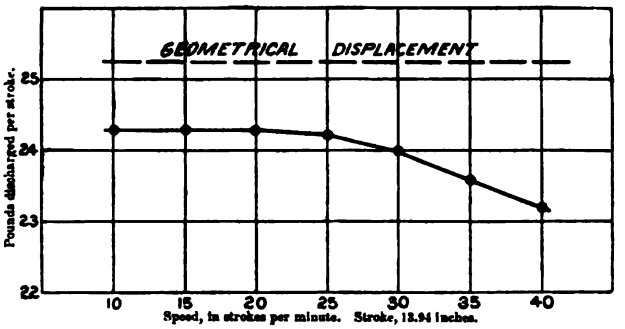


FIG. 15.—Discharge curve of 8-inch Mark pump.

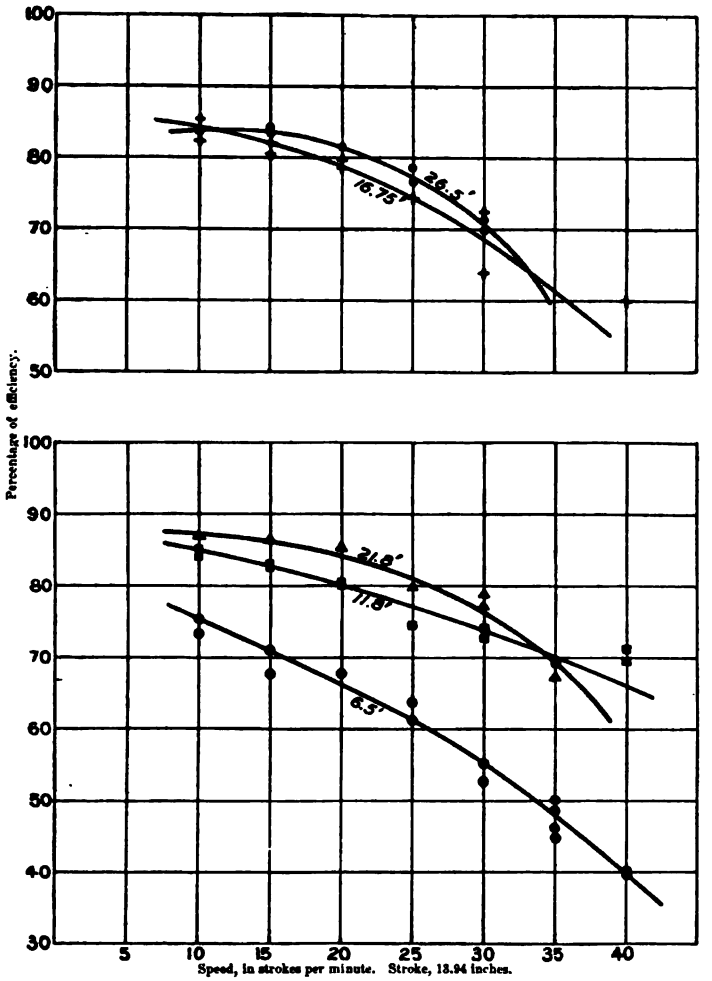


FIG. 16.—Varying-efficiency curve of 8-inch Mark pump, showing effect of varying height of lift and speed. (The line for 11.8 lift has been placed 10 per cent too high in the column 35-40. It should curve downward at the end and not cross the line 21.8.)

The lower valve is limited in movement by a cross attached to a pendent spindle on the valve disk. This valve is leather faced and has a clear opening of 36 per cent of the piston area. The upper valve area

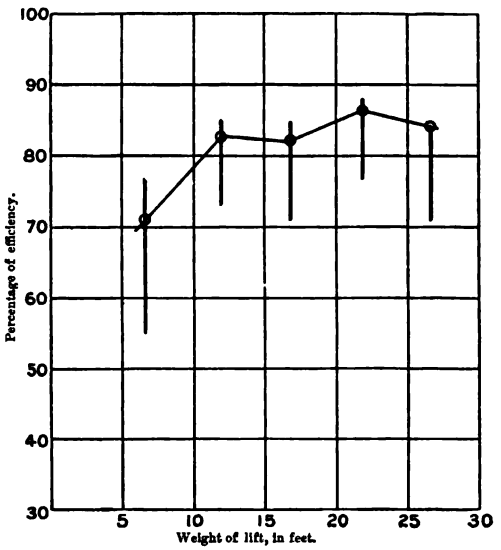


FIG. 17.—Variation of efficiency with varying height of lift of 8-inch Mark pump at speed of 15 strokes per minute.

is 34.7 per cent, the area between the edge of the disk and the cylinder walls is 53 per cent,

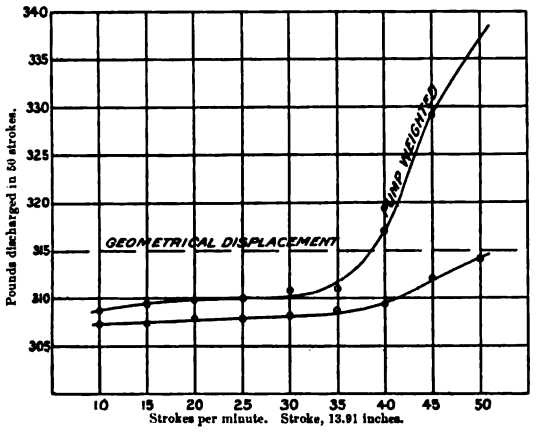


FIG. 19.—Discharge curve of 4-inch Mark pump.

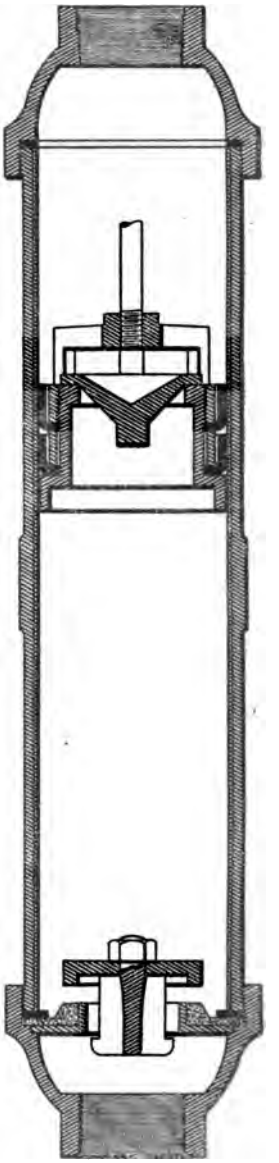


FIG. 18.—Vertical section of a brass-lined cylinder of small Mark pump.

and the area between the edge of the disk and the valve seat is slightly in excess of the valve area. The weight of the pump is 145½ pounds; of the piston and rod alone, 67½ pounds. The pump rod was a three-fourths-inch pipe, and

the delivery pipe was 6-inch. This pump is typical of the best design of those having large disk valves. It shows a very high efficiency at slow speeds, but a rapidly falling efficiency as the speed increases. Fig. 15 shows the discharge to be about 96 per cent of the geometrical displacement of the piston at a speed of 25 strokes per minute, but

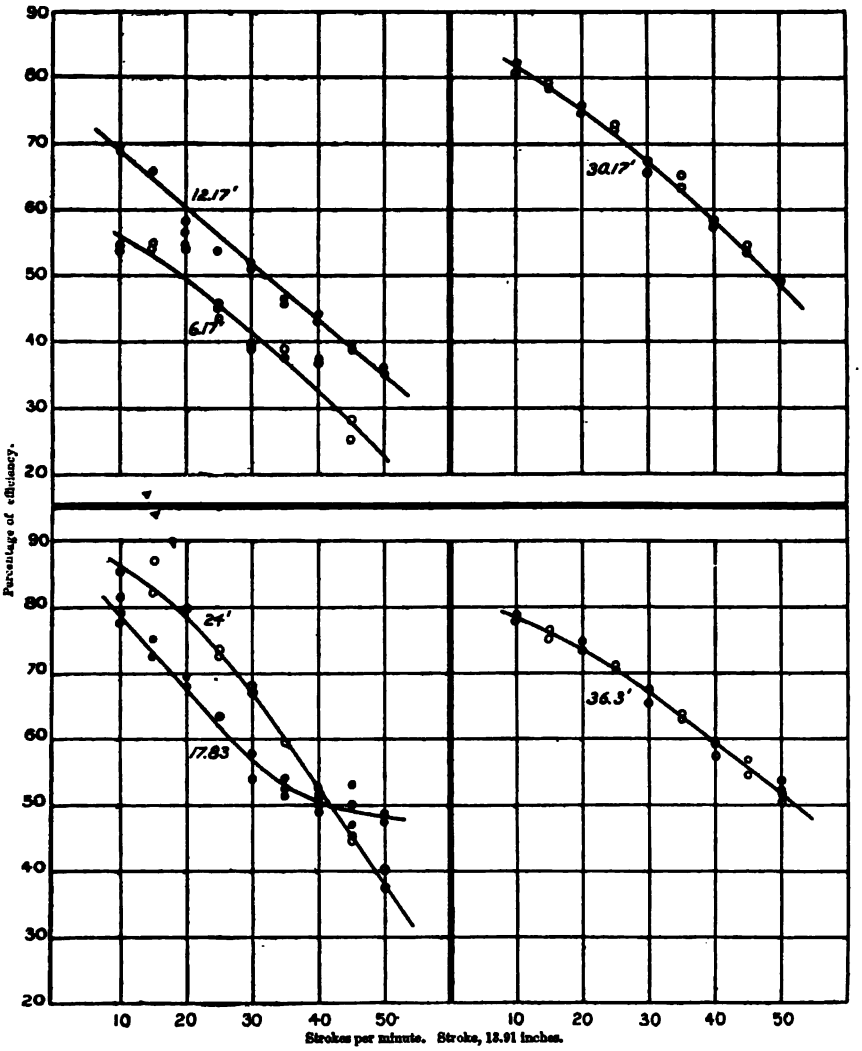


FIG. 20.—Varying-efficiency curves of 4-inch Mark pump, showing effect of varying height of lift and speed. (The lines for 17.83 and 24 should not cross. The diagram is erroneous in this respect. The correct figures for these curves are given on pages 37, 38.)

also shows that it has a falling rate beyond that speed. The efficiency is high for strokes fewer than 20 per minute, and at lifts exceeding 10 feet. Fig. 16 shows the efficiency curves at five lifts, from 6½ to 26½ feet.

In fig. 17 the heavy vertical lines show the range of efficiency at varying speeds at each lift, and the irregular line joining those points represents the efficiencies at a speed of 15 strokes per minute. It would seem from this diagram that a considerable increase of efficiency at a higher lift is not to be expected.

Fig. 18 gives a section of a brass-lined cylinder of the same make, which is typical of the better-made small pumps that provide for a suction and discharge pipe of less diameter than the cylinder. It has a 14-inch stroke, with a metal disk-valve carried in the piston. The upper valve area is 30 per cent of the cylinder area. The lower metal valve seats on a rubber ring. The lower valve area is 18 per cent. The suction and delivery pipes are 2-inch.

Fig. 19 shows two discharge curves of this pump. When rigidly

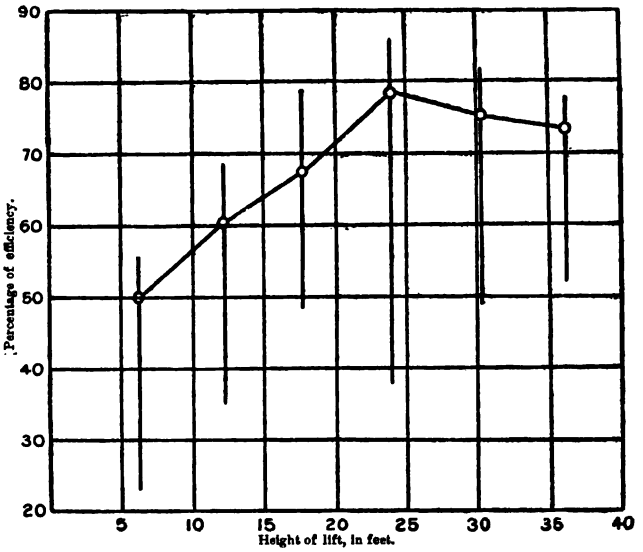


FIG. 21.—Variation of efficiency with varying height of lift of 4-inch Mark pump at speed of 20 strokes per minute.

held, so that the rapidly moving water could not jar the pump and pipe, the discharge was greater than when simply suspended in the well, as usual. The discharge is greater than the geometrical displacement of the piston at speeds above 38 strokes per minute, owing to the high velocity of the water in a small pipe. The efficiencies at six different lifts are given in the tables, and in the diagram, fig. 20. The rapidly lowering efficiency shows the effect of small connections and of small valve area.

From fig. 21 the maximum efficiency seems to be reached at about a 25-foot lift. This pump was used in an interesting test which brought out the effect of varying the suction lift. The total lift—suction and direct together—was 38 feet. The cylinder was placed at different heights in the pipe, giving different heights of suction, ranging from

nothing to 30¼ feet. Fig. 22 shows the effect on the discharge of the varying suction lift. In all cases, as the speed increases, the tendency

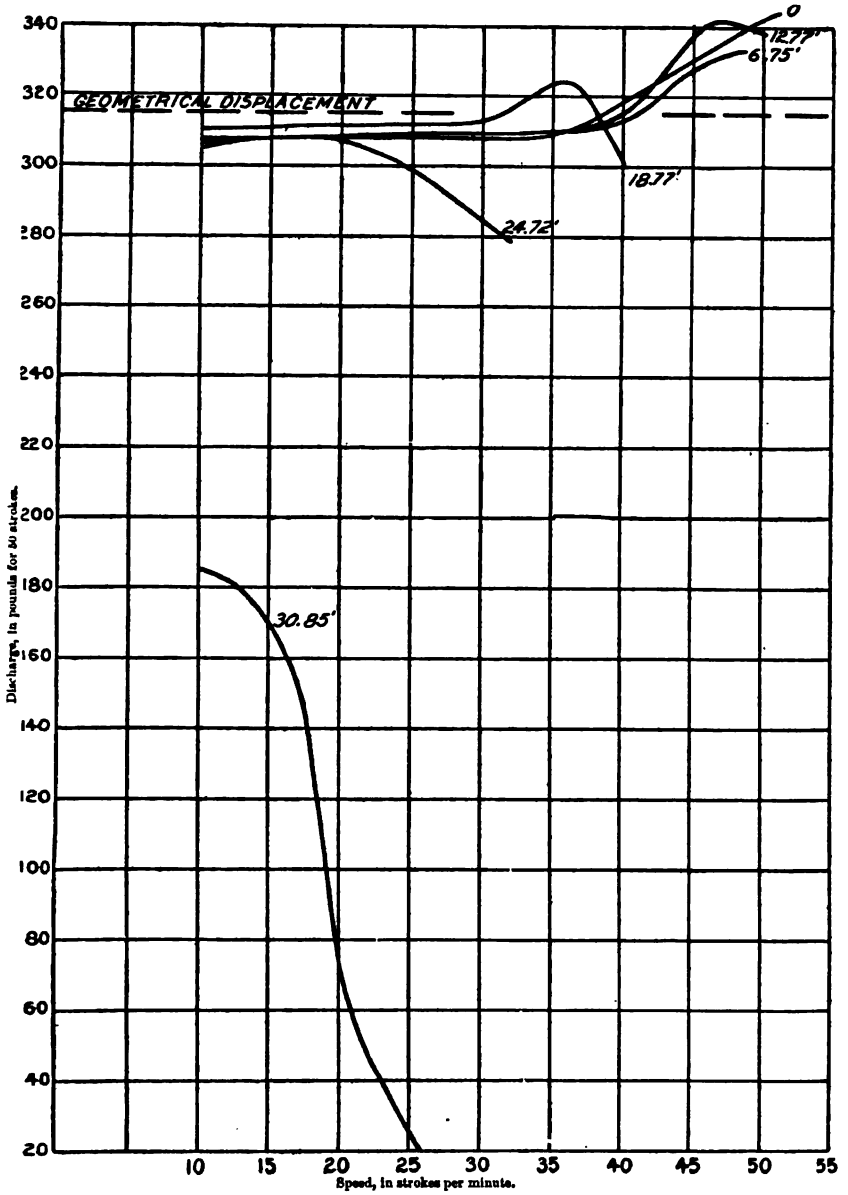


FIG. 22—Discharge curve for 4-inch Mark pump at a total lift of 38 feet and at various suction lifts.

is to increase the discharge; but when the lift gets to be so great that the atmospheric pressure is unequal to the filling of the cylinder the discharge curve rapidly falls. This maximum rise of the curve is seen

to occur earlier with each successive increase in the suction lift. Figs. 5, *B* to 6, *D* (pp. 16, 17) give diagrams of stresses in the pump-rod, and may be compared with fig. 5, *A*, which is typical of normal conditions. The tables present the results of suction tests.

Discharge of 8-inch Mark pump stroke, 13.94 inches.

Speed.[1]	Discharge for 15 strokes; lift, 6.5 feet.	Discharge for 15 strokes; lift, 11.8 feet.	Discharge for 15 strokes; lift, 26.5 feet.	Plotted average discharge per stroke.
10	367½	371	356	24.30
10	369½	369	355½	
15	366½	368½	358½	24.30
15	368	362½	357½	
20	368	369½	358	24.30
20	365½	367	358½	
25	365	369½	355½	24.266
25	365	370½	358½	
30	358	367	351½	24
30	358	361½	351½	
35	346½	358		23.60
35	348	356½		
40	337½	359		23.20
40	352	357		

[1] Strokes per minute.

Figures from efficiency tests of 8-inch Mark pump; stroke, 13.94 inches.

LIFT, 6.5 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on the rod.	Foot-pounds of work given to the rod.	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	24.300	157.95	184.72	214.28	73.7	312	72
10	24.300	157.95	179.64	208.38	75.7		
15	24.300	157.95	200	232.36	67.9		
15	24.300	157.95	191.52	222.16	71.1		
20	24.300	157.95	200	232.36	67.9		
20	24.300	157.95	200.16	232.50	67.8		
25	24.266	157.73	213.36	247.50	63.7		
25	24.266	157.73	220.32	255.57	61.8		
30	24	156	244.04	283.08	55.1		
30	24	156	252.52	292.92	53.2	648	— 72
35	23.600	153.40	284.72	330.28	46.4		
35	23.600	153.40	271.16	314.55	48.7	664	— 80
35	23.600	153.40	289.80	336.17	45.6		
35	23.600	153.40	259.32	300.81	50.9	738	—108
35	23.600	153.40	266.94	309.65	49.5		
40	23.200	150.80	325.28	377.44	39.7		
40	23.200	150.80	320.04	371.25	40.5		

LIFT, 11.8 FEET.

10	24.30	286.74	293.60	340.58	84.2	480	70
10	24.30	286.74	290.60	337.10	85		
15	24.30	286.74	297	344.52	83.2		
15	24.30	286.74	296.05	345.74	82.9		
20	24.30	286.74	308.50	357.86	80.2		
20	24.30	286.74	305.55	354.44	80.8		
25	24.266	286.34	311.95	385.06	74.3		
25	24.266	286.34	311.95	385.06	74.3		
30	24	283.20	328.95	381.58	74.2		
30	24	283.20	335.45	389.12	72.8	650	— 25
35	23.60	278.48	346.80	402.29	69.2	700	— 50
35	23.60	278.48	346.80	402.29	69.2		
40	23.20	273.76	384.60	446.14	61.3		
40	23.20	273.76	395.30	458.55	59.4	1,140	—100

Figures from efficiency tests of 8-inch Mark pump; stroke, 13.94 inches—Cont'd.

LIFT, 16.75 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on the rod.	Foot-pounds of work given to the rod.	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	24.30	407.08	426.22	494.68	82.3	585	60
10	24.30	407.08	419.85	487.45	85.1		
15	24.30	407.08	435.90	506.08	80.4		
15	24.30	407.08	429.45	498.16	81.7		
20	24.30	407.08	445.50	516.78	78.7		
20	24.30	407.08	441.97	512.69	79.5		
25	24.266	406.47	458.32	531.66	76.4		
25	24.266	406.47	467.92	542.79	74.8		
30	24.00	402.00	477.52	552.93	72.5	900	0
30	24.00	402.00	529.72	619.48	63.9		
35	23.60	395.30	555.30	644.15	61.3	1,170	—150
40	23.20	388.60	558.45	647.80	59.9	1,245	—150
40	23.20	388.60	564.82	655.20	59.3		

LIFT, 21.8 FEET.

10	24.300	529.74	536.18	607.67	87.1	825	75
10	24.300	529.74	536.18	607.67	87.1		
15	24.300	529.74	539.47	611.40	86.6		
15	24.300	529.74	539.47	611.40	86.6		
20	24.300	529.74	549.30	622.54	85.1		
20	24.300	529.74	546.00	618.80	85.6	960	75
25	24.266	529.01	582.24	659.87	80.2	997.5	—37.5
25	24.266	529.01	583.65	661.47	79.9		
30	24.000	523.20	595.35	674.73	77.5		
30	24.000	523.20	595.35	674.73	77.5		
30	24.000	523.20	585.52	663.59	78.8		
35	23.600	514.48	684.15	775.37	69.8	1,387.5	—165
35	23.600	514.48	707.17	811.46	67.5		

LIFT, 28.5 FEET.

10	24.300	643.95	684.15	775.37	83.5	997.5	45.0
10	24.300	643.95	680.85	771.83	83.6		
15	24.300	643.95	677.62	767.97	83.8		
15	24.300	643.95	674.32	764.23	84.2		
20	24.300	643.95	694.05	786.59	81.8		
20	24.300	643.95	697.35	790.33	81.4		
25	24.266	643.06	720.37	816.42	78.7	1,275	—37.5
25	24.266	643.06	740.77	839.44	76.6		
30	24.000	630.00	786.15	890.97	71.3		
30	24.000	630.00	801.67	908.56	69.9		

Discharge of 4-inch Mark pump at various speeds and lifts.

Speed.	Discharge, in pounds, for 50 strokes for lift:				Average discharge, in pounds, per stroke by discharge curve.
	6.17 feet.	12.17 feet.	24.2 feet.	30.17 feet.	
10	309.5	311	304	307	6.146
10	308.5	309.5	308.5	307.5	
15	308	312	305	309	6.148
15	306	309	305.5	308	
20	308	310.5	308	307	6.152
20	305.5	310.5	308.5	308	
25	308	310.5	309	307	6.156
25	305.5	308	308.5	309.5	
30	308	308	312.5	309	6.16
30	306	307	309.5	307	
35	309	308.5	310	307	6.17
35	309	308.5	311	308.5	
40	306	309.5	311.5	311	6.192
40	306.5	308.5	309	313	
45	300	312	321		6.24
45	301	310.5	328.5		
50		314.5			6.28
50		313.5			

Discharge of 4-inch Mark pump at various lifts and speeds; pump cylinder heavily weighted.

Speed.	Discharge, in pounds, for 50 strokes for lift:		Average discharge, in pounds, per stroke by discharge curve.	Speed.	Discharge, in pounds, for 50 strokes for lift:		Average discharge, in pounds, per stroke by discharge curve.
	30.17 feet.	36.3 feet.			30.17 feet.	36.3 feet.	
10	308.5	305.5	6.16	30	311.5	310	
10	308.5	303.5		35	311	310.5	6.23
15	311.5	308.5	6.192	35	311.5	310.5	
15	312	307		40	314.5	321	6.34
20	311.5	308.5	6.196	40	317	316	
20	312	307.5		45	332	328	6.584
25	312	308	6.198	45	328	329	
25	310.5	309		50	339.5	331.5	6.744
30	312	309.5	6.204	50	341	337	

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches.

LIFT, 6.17 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.146	37.92	60.58	70.21	54	81
10	6.146	37.92	59.93	69.46	54.6	
15	6.148	37.94	60.58	70.21	54	
15	6.148	37.94	59.62	69.1	54.9	
20	6.152	37.96	59.68	69.17	54.8	
20	6.152	37.96	60.58	70.21	54	
20	6.152	37.96	59.23	68.65	55.3	107
25	6.156	37.98	72.44	83.95	45.2	
25	6.156	37.98	71.47	82.84	45.8	132
25	6.156	37.98	75	78.12	43.6	
30	6.16	38.01	82.37	95.47	39.8	
30	6.16	38.01	83.97	97.33	39	158
35	6.17	38.07	86.86	100.7	37.8	159
35	6.17	38.07	86.86	100.7	37.8	
40	6.192	38.21	88.5	102.5	37.2	
40	6.192	38.21	89.42	103.6	36.8	
45	6.24	38.5	117.4	136.1	28.2	
45	6.24	38.5	131.8	152.8	25.2	294
48	6.27	38.69	173.3	200.9	19.2	

LIFT, 12.17 FEET.

10	6.146	74.8	93	107.8	69.3	117
10	6.146	74.8	92.6	107.3	69.6	
15	6.148	74.82	97.7	113.4	65.9	159
15	6.148	74.82	97.7	113.4	65.9	
20	6.152	74.87	110.7	128.3	58.3	147
20	6.152	74.87	113.6	131.7	56.8	
25	6.156	74.92	120.8	140	53 5	
25	6.156	74.92	120.2	139.3	53.7	
30	6.16	74.97	124.3	144.1	52	
30	6.16	74.97	126.6	146.7	51	223
35	6.17	75.09	139.1	161.2	46.5	255
35	6.17	75.09	140.1	162.4	46.2	
40	6.192	75.3	146.5	169.8	44.4	
40	6.192	75.3	150	173.8	43.3	300
45	6.24	75.94	166.7	193.2	39.3	
45	6.24	75.94	165.4	191.7	39.6	366
50	6.28	76.4	187	216.8	35.2	
50	6.28	76.4	182.7	211.7	36.1	372

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches—Continued.

LIFT, 17.83 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.146	109.6	119.5	139	79.1	210
10	6.146	109.6	121.5	140.9	77.8	.....
15	6.148	109.6	126.1	146.1	75	.....
15	6.148	109.6	130.5	151.3	72.4	.....
20	6.152	109.7	139	161.1	68	.....
20	6.152	109.7	135.7	157.3	69.7	225
25	6.156	109.8	137	158.8	69.1	264
25	6.156	109.8	148.7	172.4	63.7	270
30	6.16	109.8	162.9	188.8	58.1	375
30	6.16	109.8	175.1	202.9	54.1	411
35	6.17	110	183.5	212.6	51.7	432
35	6.17	110	175.6	206.3	52.8	420
40	6.192	110.4	184.3	213.6	51.7	.....
40	6.192	110.4	189.4	219.6	50.3	489
45	6.24	111.3	211.8	245.5	45.3	555
45	6.24	111.3	213.7	248.7	44.9	.....
50	6.28	112	239.5	277.6	40.3	.....
50	6.28	112	257.5	298.4	37.5	684

LIFT, 24.2 FEET.

10	6.146	148.7	150	173.8	85.5	228
10	6.146	148.7	157.2	182.2	81.6	234
10	6.146	148.7	147.4	170.8	87	225
15	6.148	148.8	156.5	181.4	82	255
15	6.148	148.8	156.5	181.4	82	258
20	6.152	148.9	161.1	186.7	79.7	285
20	6.152	148.9	161.1	186.7	79.7	285
25	6.156	149	177.3	205.5	72.5	348
25	6.156	149	174.7	202.5	73.6	345
30	6.16	149.1	188.8	218.8	68.1	447
30	6.16	149.1	191.4	221.8	67.2	471
35	6.17	149.3	215.3	249.5	59.8	558
35	6.17	149.3	200.4	232.3	64.2	501
40	6.192	149.8	262.7	304.4	49.2	720
40	6.192	149.8	244.6	283.5	52.8	669
45	6.24	151	243.6	282.3	53.5	665
45	6.24	151	242.4	281	53.7	640
45	6.24	151	275.8	319.6	47.2	.....
45	6.24	151	257.5	298.4	50.6	760
50	6.28	152	267.2	309.5	49	775
50	6.28	152	274.7	318.4	47.7	775

LIFT, 30.17 FEET.

10	6.146	185.4	195.6	226.7	81.7	300
10	6.146	185.4	191.3	221.7	83.6	305
15	6.148	185.5	198.9	230.5	80.4	330
15	6.148	185.5	200	231	80	345
20	6.152	185.6	206.7	239.6	77.4	330
20	6.152	185.6	206.7	239.6	77.4	390
25	6.156	185.7	208.9	242	76.7	410
25	6.156	185.7	211	244.6	75.9	410
30	6.16	185.8	235.9	273.4	67.9	535
30	6.16	185.8	234.8	272.2	68.2	535
35	6.17	186.1	255.4	296	62.8	650
35	6.17	186.1	257.6	298.5	62.3	675
40	6.192	186.8	260.8	302.3	61.8	675
40	6.192	186.8	265.1	307.3	60.8	700
45	6.24	188.2	283.4	328.5	57.3	830
45	6.24	188.2	288.8	334.7	56.2	820

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches—Continued.

LIFT, 30.17 FEET.

[Pump heavily weighted.]

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.16	185.8	195.9	227	81.8	315
10	6.16	185.8	194.8	225.8	82.3	305
15	6.192	186.8	204.3	236.8	78.8	350
15	6.192	186.8	203.2	235.6	79.3	350
20	6.196	186.9	216.3	250.7	74.5	410
20	6.196	186.9	213	246.9	75.7	415
25	6.198	187	222.8	258.2	72.4	490
25	6.198	187	220.6	255.7	72.7	480
30	6.204	187.2	240.3	278.5	67.2	575
30	6.204	187.2	245.7	284.7	65.7	595
35	6.23	187.9	248.9	288.5	65.1	620
35	6.23	187.9	254.3	294.7	63.7	615
40	6.34	191.2	281.2	326	58.6	730
40	6.34	191.2	285.5	330.9	57.8	755
45	6.58	197.6	318.7	369.4	53.7	880
45	6.58	197.6	314.1	364	54.5	845
50	6.744	203.5	356.8	413.6	49.2	1,000

LIFT, 36.3 FEET.

[Pump heavily weighted.]

10	6.16	223.6	244.6	283.5	78.9	355
10	6.16	223.6	245.6	284.7	78.5	350
15	6.192	224.8	253.3	293.5	76.5	415
15	6.192	224.8	256.5	297.3	75.6	440
20	6.196	224.9	263	304.8	73.8	465
20	6.196	224.9	259.7	301	74.7	465
25	6.198	225	272.7	316.1	71.1	560
25	6.198	225	273.8	317.3	70.9	570
30	6.204	225.2	287.7	333.5	67.5	680
30	6.204	225.2	296.3	343.4	65.5	700
35	6.23	226.1	307.9	356.9	63.3	760
35	6.23	226.1	306.9	355.7	63.6	760
40	6.34	230.2	335.8	389.3	59.1	875
40	6.34	230.2	343.3	398	57.8	925
45	6.584	239	360.5	417.9	57.2	925
45	6.584	239	367	425.3	54.9	985
50	6.744	244.8	418 5	485	50.4	1,035
50	6.744	244.8	391.6	453.9	53.9	1,000
50	6.744	244.8	403.4	467.6	52.3	1,050
50	6.744	244.8	403.4	467.6	52.3	1,065
50	6.744	244.8	409.9	475.1	51.5	1,000

Plotted averages of discharge per stroke, suction test of 4-inch Mark pump.

Speed.	Discharge, in pounds, per stroke.					
	Total lift, 38 feet; suction lift, 30.85 feet.	Total lift, 37.96 feet; suction lift, 24.77 feet.	Total lift, 38 feet; suction lift, 18.77 feet.	Total lift, 37.96 feet; suction lift, 12.77 feet.	Total lift, 37.92 feet; suction lift, 6.73 feet.	Total lift, 37.92 feet; suction lift, 0.6 foot.
10	185.5	6.11	6.21	6.16	6.13	6.14
15	172.5	6.154	6.228	6.168	6.16	6.15
20	79.5	6.15	6.23	6.176	6.168	6.156
25	25.5	5.996	6.234	6.184	6.174	6.16
30	7.5	5.730	6.256	6.192	6.178	6.164
35			6.46	6.2	6.184	6.184
40			6.024	6.266	6.250	6.34
45				6.754	6.56	6.556
50				6.78	6.68	6.706

Discharges of 4-inch Mark pump at various suction lifts and speeds.

Speed.	Discharge, in pounds, for 50 strokes.					
	Total lift, 38 feet; suction lift, 30.85 feet.	Total lift, 37.96 feet; suction lift, 24.77 feet.	Total lift, 38 feet; suction lift, 18.77 feet.	Total lift, 37.96 feet; suction lift, 12.77 feet.	Total lift, 37.92 feet, suction lift, 6.73 feet.	Total lift, 38.08 feet; suction lift, 0.6 foot.
10	185.5	308	311.5	308.5	306.5	306.5
10		305	309.5	307.5	306.5	307.5
15	172.5	310.5	311	306.5	307.5	307
15		305	312	309.5	306.5	308
20	79.5	308.5	312.5	307.5	309	306.5
20		306.5	310	310	309.5	307
25	25.5	299.5	313	310.5	308.5	307
25		300	311	309	308.5	309.5
30	7.5	290	312.5	308	309	308
30		283.5	313	309	309	307
35			323	311	309.5	311.5
35			323	309	309	307
40			301.5	312.5	312.5	318.5
40			301	314		318.5
45				337.5	328	
45				338		
50				340	334	331.5
50				338		339

Figures from suction test of 4-inch Mark pump.

TOTAL LIFT, 38.08 FEET; SUCTION LIFT, 0.6 FOOT.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.14	233.8	253.3	293.6	79.6	350
10	6.14	233.8	256.6	297.4	78.6	370
15	6.15	234.2	257.7	298.6	78.4	390
15	6.15	234.2	257.7	298.6	78.4	400
20	6.156	235.4	263.1	304.9	76.8	460
20	6.156	235.4	267.5	310	75.6	470
20	6.156	235.4	264.2	306.2	76.5	470
25	6.16	235.5	275.1	318.8	73.5	530
25	6.16	235.5	276.1	320	73.3	530
30	6.164	235.7	297.8	345.2	68	710
30	6.164	235.7	316.3	366.6	64	760
35	6.184	235.6	322.8	374.2	62.9	780
35	6.184	235.6	340.2	394.3	59.7	860
40	6.34	241.4	359.3	416.4	57.9	910
40	6.34	241.4	368	426.5	56.6	920
45	6.556	249.6	394	456.6	54.6	990
45	6.556	249.6	390.7	452.8	55.1	1,000
50	6.706	255.4	415.6	481.7	53	1,090
50	6.706	255.4	418.8	485.4	52.6	1,080

TOTAL LIFT, 37.92 FEET; SUCTION LIFT, 6.73 FEET.

10	6.13	232.4	245.1	284	81.8	380
10	6.13	232.4	243.5	282.2	82.3	375
15	6.16	233.6	256.5	297.3	78.5	435
15	6.16	233.6	255.5	296.1	78.9	435
20	6.168	233.9	266.4	308.7	75.7	490
20	6.168	233.9	270.7	313.8	74.5	505
25	6.174	234.1	287.1	332.8	70.3	585
25	6.174	234.1	292.6	339.1	69	620
30	6.178	234.2	302.2	350.2	66.9	660
30	6.178	234.2	315.2	365.3	64.1	720
35	6.184	234.5	332.2	385.1	60.9	785
35	6.184	234.5	332.2	385.1	60.9	800
40	6.25	237	359.9	416.9	56.8	870
40	6.25	237	381.5	442.1	53.6	950
45	6.56	248.8	422.4	489.6	50.8	1,005
45	6.56	248.8	404.1	468.3	53.1	960
50	6.68	253.3	468.8	543.3	46.6	1,160
50	6.68	253.3	472	547.1	46.3	1,050

Figures from suction test of 4-inch Mark pump—Continued.

TOTAL LIFT, 37.96 FEET; SUCTION LIFT, 12.77 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.16	233.8	254.4	294.8	79.3	370
10	6.16	233.8	252.2	292.3	80	380
15	6.168	234	256	296.7	78.9	410
15	6.168	234	260.4	301.8	77.5	410
20	6.176	213.8	263.1	304.9	76.8	460
20	6.176	213.8	264.2	306.2	76.5	440
25	6.184	234.7	277.3	321.4	73	560
25	6.184	234.7	282.8	327.7	71.6	560
30	6.192	235	301.3	349.2	67.3	650
30	6.192	235	299.1	346.7	67.8	640
35	6.2	235.4	319.6	370.4	63.5	715
35	6.2	235.4	318.5	369.1	63.7	705
40	6.266	237.9	394.6	457.3	52	915
45	6.754	256.4	414.1	480	53.4	885
45	6.754	256.4	407.6	472.4	54.2	885
45	6.754	256.4	439.1	508.9	50.3	----------
45	6.754	256.4	430.4	498.9	51.4	----------
50	6.78	257.4	431.8	500.5	51.4	----------
50	6.78	257.4	443.7	514.3	50	1,000

TOTAL LIFT, 38 FEET; SUCTION LIFT, 18.77 FEET.

10	6.21	236	239.1	277.1	85.1	310
10	6.21	236	241.2	279.6	84.4	325
15	6.226	236.6	254.4	294.8	80.2	----------
15	6.226	236.6	250	289.8	81.6	385
20	6.23	236.7	268.5	311.2	76	465
20	6.23	236.7	264.1	306.1	77.3	440
25	6.234	236.9	271.7	314.9	75.2	485
25	6.234	236.9	271.7	314.9	75.2	490
30	6.256	237.7	302.2	350.2	67.8	550
30	6.256	237.7	302.2	350.2	67.8	555
30	6.256	237.7	303.8	352.1	67.5	570
35	6.46	245.5	350.2	405.9	60.4	725
35	6.46	245.5	340.5	394.7	62.2	765
40	6.024	225.7	365.7	423.9	54	830
40	6.024	225.7	355.9	422.1	55.5	----------
40	6.024	225.7	364.6	422.6	54.1	870
40	6.024	225.7	364.6	422.6	54.1	----------

TOTAL LIFT, 37.96 FEET; SUCTION LIFT, 24.77 FEET.

10	6.11	231.9	240.1	278.3	83.3	290
10	6.11	231.9	241.2	279.6	82.9	285
15	6.154	233.6	250	289.8	80.6	310
15	6.154	233.6	248.9	288.5	80.9	305
20	6.15	233.5	258.7	299.9	77.8	345
20	6.15	233.5	258.4	311.1	75	365
20	6.15	233.5	269.5	312.3	74.7	370
20	6.15	233.5	273.8	317.4	73.5	375
20	6.15	233.5	259.8	301.1	77.5	345
25	5.996	227.6	291.7	338	67.3	425
25	5.996	227.6	291.5	337.8	67.3	500
25	5.996	227.6	286	331.5	68.6	415
25	5.996	227.6	287.1	332.8	68.4	525
25	5.996	227.6	292.8	339.3	67	405
30	5.73	213.7	279.5	323.9	65.9	585
30	5.73	213.7	270.7	313.8	68.1	475

TOTAL LIFT, 38 FEET; SUCTION LIFT, 30.85 FEET.

10	3.71	141	178.3	206.6	68.2	265
10	3.71	141	178.3	206.6	68.2	285
15	3.45	131.1	165.2	191.5	68.4	265
15	3.45	131.1	175	202.8	64.6	265
20	1.59	60.4	116.8	135.4	44.6	270
20	1.59	60.4	125	144.9	41.7	270
25	.516	19.6	98	113.9	17.21	270
25	.516	19.6	102.6	118.9	16.4	275
30	.14	5.32	109.8	127.2	4.1	285
30	.14	5.32	81.1	94	5.6	295

FRIZELL PUMP.

Fig. 23 represents a piston pump having a valve chamber surrounding the cylinder, and containing eight small clack discharge valves.

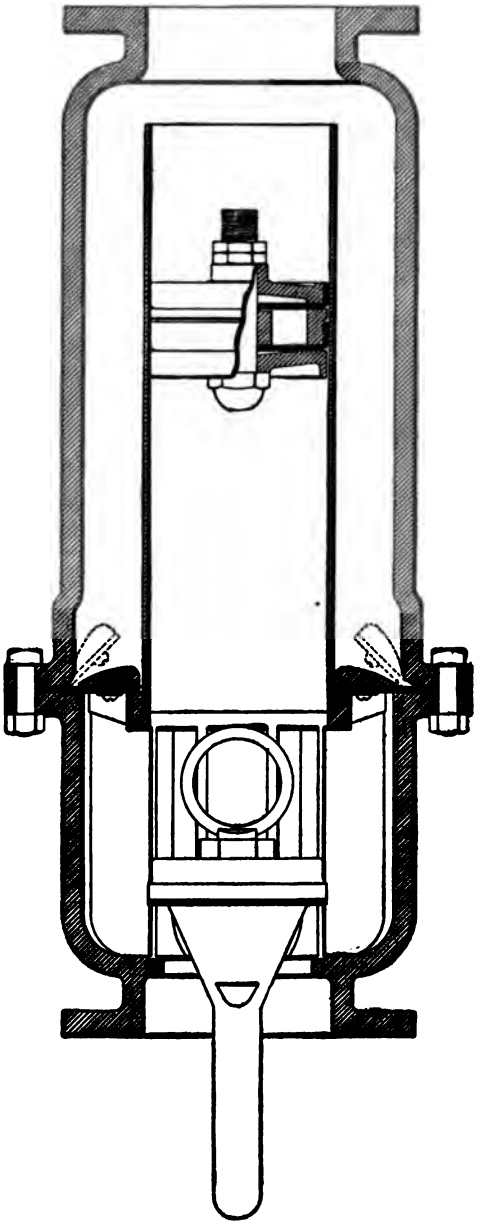


FIG. 23.—Vertical section of piston pump with valve chamber surrounding cylinder.

The suction valve is a heavy disk valve, playing in a special suction chamber, guided at its circumference, and not limited in its rise. It

is arranged to withdraw through the cylinder if necessary. On the upstroke water is drawn into the cylinder through the suction valve;

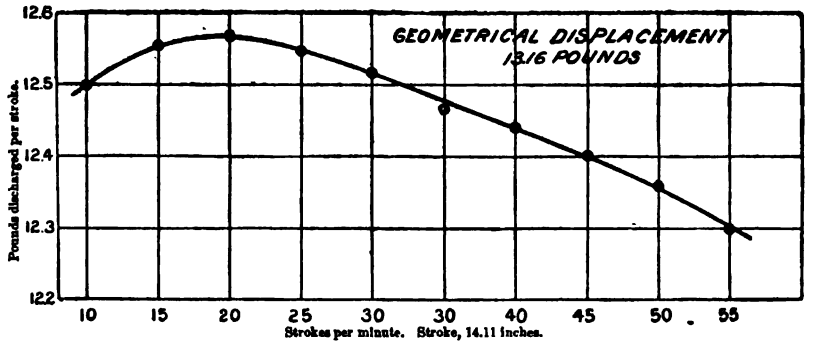


FIG. 24.—Discharge curve of 6-inch Frizell pump.

on the downstroke this water is forced through the delivery valves into the space above the piston, and is lifted on the next upstroke.

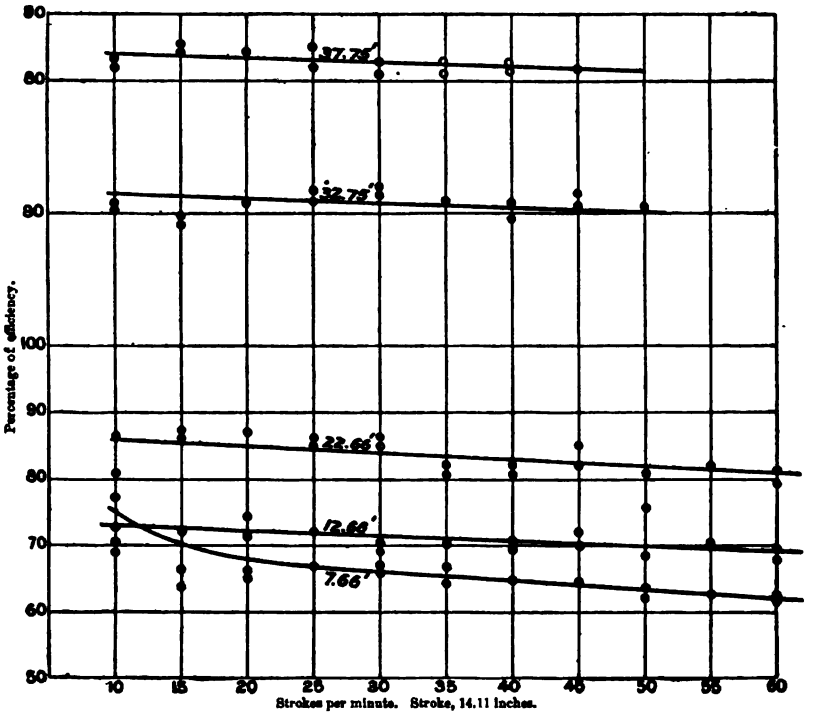


FIG. 25.—Varying-efficiency curves of 6-inch Frizell pump, showing effect of varying height of lift and speed.

The suction-valve area is 59½ per cent of the cylinder area; the cylinder diameter, 5.74 inches; the upper valve seat area, 29.7 inches, or

3.8 inches more than the cylinder area; the weight of the pump, 270 pounds, and the weight of piston, rod, etc., 62 pounds. This pump was designed especially for irrigation purposes, and is known as the "Frizell" pump. It is remarkable for its sustained efficiency at high speeds. So far as tested the speed was limited only by the ability of connections to stand the work. Fig. 24 gives the discharge per stroke, which reaches a maximum of 95½ per cent of the geometrical displacement. Fig. 25 shows efficiency curves for five lifts. The small dif-

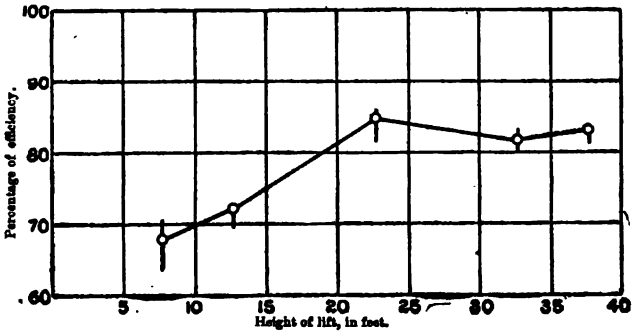


FIG. 26.—Variation of efficiency with varying height of lift of 6-inch Frizell pump at speed of 20 strokes per minute.

ference of efficiency at different speeds is due to the employment of large valve areas and small quick-closing valves. Fig. 26 shows that efficiency varies with the lift, being at its best probably at about 25 feet. The tables present the details of the tests.

Discharge of 6-inch Frizell pump at various lifts and speeds.

Speed.	Discharge in 30 strokes, lift 7.66 feet.	Discharge in 30 strokes, lift 12.66 feet.	Discharge in 30 strokes, lift 22.75 feet.	Plotted averages per stroke.
10	378	367	377	12.50
10	377		378	
15	377	371	380	12.56
15	379	371	383½	
20	377	373½	381½	12.57
20	378½	372½		
25	382	370	380	12.55
25		370	382	
30	375	366½	381½	12.52
30	379	369	376	
35	374	371	377½	12.47
35	371	365	374½	
40	379	370	379	12.44
40	375½	365½	374½	
45	374	365½	376	12.40
45	373	367	373	
50	377½–378	372	370½	12.36
50	380 –379	364	369	
50	371½–374			
55	363	364		12.30
55	371 –370	359		
60	372	361		12.22
60	371 –371	357		

Figures from efficiency tests of 6-inch Frizell pump; stroke, 19.. inches.

LIFT, 7.66 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	12.50	95.75	106.37	124.11	77.1	.....	.....
10	12.50	95.75	111.70	131.36	72.8	.....	.....
15	12.56	96.21	124.45	146.35	66.4	.....	.....
15	12.56	96.21	127.65	150.12	64.1	.....	.....
20	12.57	96.28	124.45	146.35	65.7	.....	.....
20	12.57	96.28	123.40	145.12	66.3	.....	.....
25	12.55	96.13	122.35	143.88	66.8	.....	.....
25	12.55	96.13	122.88	144.50	66.5	.....	.....
30	12.52	95.90	123.40	145.12	66	.....	.....
30	12.52	95.90	121.30	142.65	67.2	.....	.....
35	12.47	95.52	121.30	142.65	66.9	.....	.....
35	12.47	95.52	125.53	147.61	64.7	.....	.....
40	12.44	95.29	125.53	147.61	64.5	.....	.....
40	12.44	95.29	125.53	147.61	64.5	.....	.....
45	12.40	94.98	125.53	147.61	64.3	.....	.....
45	12.40	94.98	124.45	146.35	64.9	.....	.....
50	12.36	94.68	126.56	148.84	63.6	800	−30
50	12.36	94.68	128.16	150.72	62.8	.....	.....
55	12.30	94.22	128.16	150.72	62.5	.....	.....
55	12.30	94.22	128.16	150.72	62.5	.....	.....
60	12.22	93.60	128.16	150.72	62.1	.....	.....
60	12.22	93.60	129.26	152	61.5	.....	.....

LIFT, 12.66 FEET.

10	12.50	158.25	191.45	225.15	70.3	300	65
10	12.50	158.25	192.80	226.70	69.8	.....	.....
15	12.56	159	186.95	220.25	72.1	310	40
15	12.56	159	187.75	220.79	72	.....	.....
20	12.57	159.14	181.40	213.33	74.6	.....	.....
20	12.57	159.14	189.35	223.67	71.4	.....	.....
25	12.55	158.98	187.20	220.15	72.2	.....	.....
25	12.55	158.98	188.55	221.74	71.7	.....	.....
30	12.52	158.50	192.80	226.73	69.9	.....	.....
30	12.52	158.50	191.45	225.15	70.3	.....	.....
35	12.47	157.86	191.45	225.15	70.1	.....	.....
35	12.47	157.86	191.45	225.15	70.1	.....	.....
40	12.44	157.49	189.35	222.67	70.7	.....	.....
40	12.44	157.49	191.45	225.15	69.9	750	−75
45	12.40	156.98	190.65	224.21	70	750	−80
45	12.40	156.98	185.10	217.68	72.1	.....	.....
50	12.36	156.58	187.70	219.15	75.9	.....	.....
50	12.36	156.58	194.44	228.66	68.4	.....	.....
55	12.30	155.72	188.55	221.74	70.2	850	−70
55	12.30	155.72	188.55	221.74	70.2	.....	.....
60	12.22	154.70	192.80	226.73	68.2	.....	.....
60	12.22	154.70	180.35	222.67	69.4	.....	.....

LIFT, 22.66 FEET.

10	12.50	283.25	277.50	326.34	86.7	410	60
10	12.50	283.25	.....	.....	80.6	.....	.....
15	12.56	284.61	279.65	328.87	86.4	.....	.....
15	12.56	284.61	277.50	326.34	87.2	.....	.....
20	12.57	284.84	277.50	326.34	87.3	.....	.....
20	12.57	284.84	277.50	326.34	87.3	.....	.....
25	12.55	284.38	282.70	332.35	85.6	.....	.....
25	12.55	284.38	280.60	329.98	86.2	.....	.....
30	12.52	283.70	282.70	332.35	85.3	500	−85
30	12.52	283.70	284.80	334.92	84.4	.....	.....
35	12.47	282.56	291.10	342.33	82.6	.....	.....
35	12.47	282.56	296.35	347.33	81.3	.....	.....
40	12.44	281.89	296.35	347.33	81	770	−85
40	12.44	281.89	291.10	342.33	82.3	.....	.....
45	12.40	280.98	291.10	342.33	81.8	.....	.....
45	12.40	280.98	284.80	332.12	84.6	930	−50
50	12.36	280.08	294.40	346.12	80.9	925	−100
50	12.36	280.08	296.35	347.33	80.6	.....	.....
55	12.30	278.72	292.10	343.39	81.1	.....	.....
55	12.30	278.72	291.10	342.33	81.4	1,050	−100
60	12.22	276.90	290.25	341.34	81.1	.....	.....
60	12.22	276.90	296.20	348.33	79.4	.....	.....

Figures from efficiency tests of 6-inch Frizell pump; stroke, 19.1 inches—Continued.

LIFT, 32.75 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	12.50	409.38	426.38	512	81.3	.....	.....
10	12.50	409.38	431.25	507.15	80.7	.....	.....
15	12.56	411.34	441.60	519.32	79.2	.....	.....
15	12.56	411.34	444.90	523.20	78.6	.....	.....
20	12.57	422.06	440.40	517.91	81.5	.....	.....
20	12.57	422.06	441.60	591.32	81.7	.....	.....
25	12.55	421.41	429	504.50	83.5	.....	.....
25	12.55	421.41	435.38	512	82.1	.....	.....
30	12.52	420.43	425.85	500.90	83.9	720	—30
30	12.52	420.43	431.25	507.15	82.9	.....	.....
35	12.47	408.39	424.42	499.12	81.8	.....	.....
35	12.47	408.39	424.42	499.12	81.8	.....	.....
40	12.44	407.41	430.80	506.62	81.3	.....	.....
40	12.44	407.41	435.08	510.42	79.8	1,050	—97.5
45	12.40	406.10	425.20	500.04	81.1	1,027.5	—90
45	12.40	406.10	419.47	493.29	82.9	.....	.....
50	12.36	404.79	425.20	500.04	80.9	.....	.....
50	12.36	404.79	425.20	500.04	80.9	1,260	—60

LIFT, 37.75 FEET.

10	12.50	471.87	484.25	573.97	82.2	.....	.....
10	12.50	471.87	484.87	566.68	83.2	.....	.....
15	12.56	474.14	478.72	562.97	85.3	.....	.....
15	12.56	474.14	475.50	559.19	84.7	.....	.....
20	12.57	474.52	476.62	560.40	84.6	.....	.....
20	12.57	474.52	479.77	564.21	84.1	.....	.....
25	12.55	473.76	493.52	579.20	81.7	750	0
25	12.55	473.76	486.22	561.79	84.8	.....	.....
30	12.52	472.63	483	568	83.2	.....	.....
30	12.52	472.63	495.75	583	81	.....	.....
35	12.47	470.74	492.52	579.20	81.2	.....	.....
35	12.47	470.74	483	568	82.8	1,020	—67.5
40	12.44	469.61	489.38	575.51	81.6	.....	.....
40	12.44	469.61	486.22	571.79	82.3	1,005	—67.5
45	12.40	468.10	486.22	571.79	81.9	.....	.....

In the smaller size of this same make, fig. 27, a single butterfly valve in the piston replaces the several small clack valves. The cylinder is

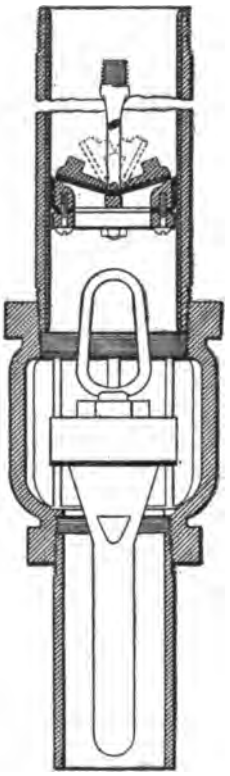


FIG. 27.—Vertical section of Frizell cylinder with butterfly valve.

brass-lined, is 3.73 inches in diameter, and has a 24-inch stroke. The valve area in the piston is 27.4 per cent of the cylinder area; the suc-

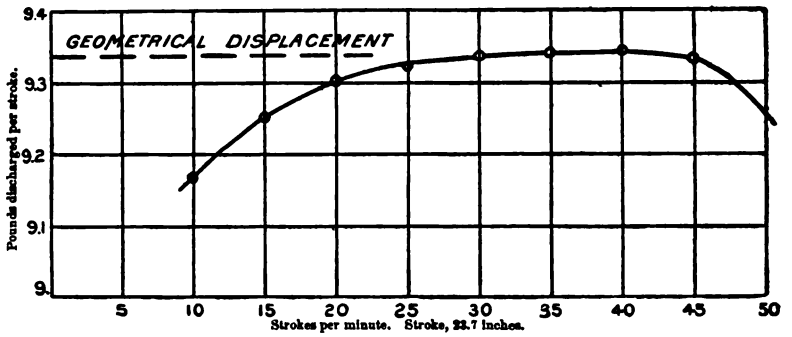


FIG. 28.—Discharge curve of 4-inch Frizell pump.

tion valve, 56 per cent; the weight of the pump, 57½ pounds, and the weight of piston, rod, etc., 39½ pounds. Fig. 28 shows a discharge

attaining to 100 per cent at speeds ranging from 25 to 40 strokes per minute. Fig. 29 shows the efficiency at six different lifts. The sustained efficiency of this pump is noticeable. In fig. 30 increase of efficiency with increase of lift appears. This pump is much used in Kansas for irrigation.

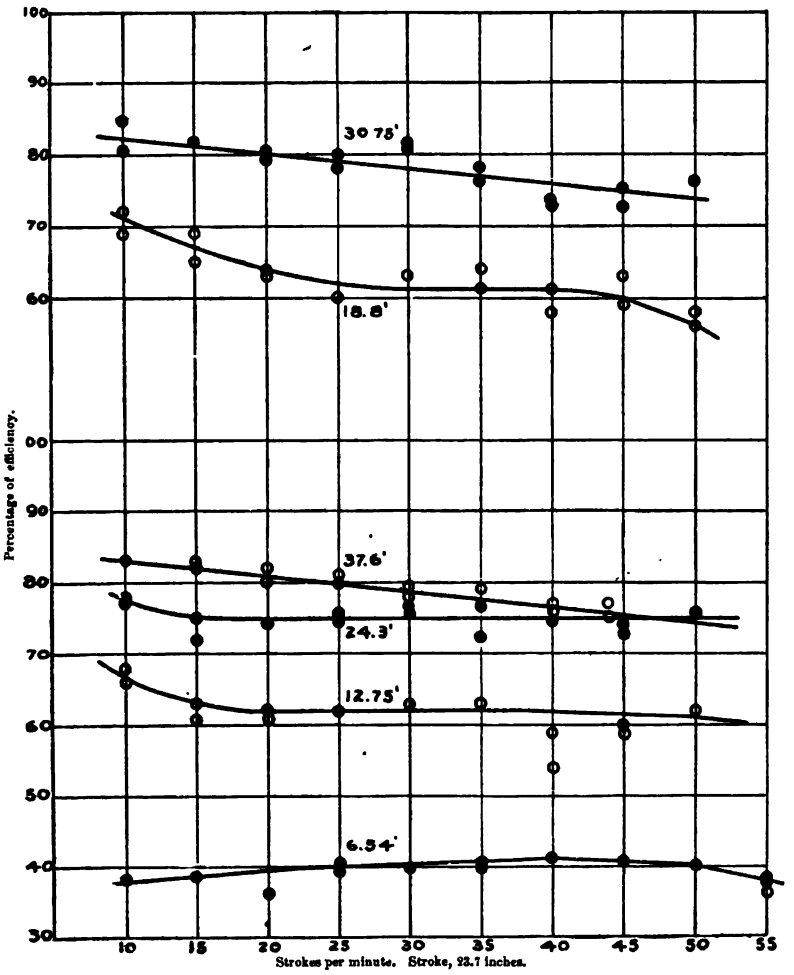


FIG. 29.—Varying-efficiency curves of 4-inch Frizell pump, showing effect of varying height of lift and speed.

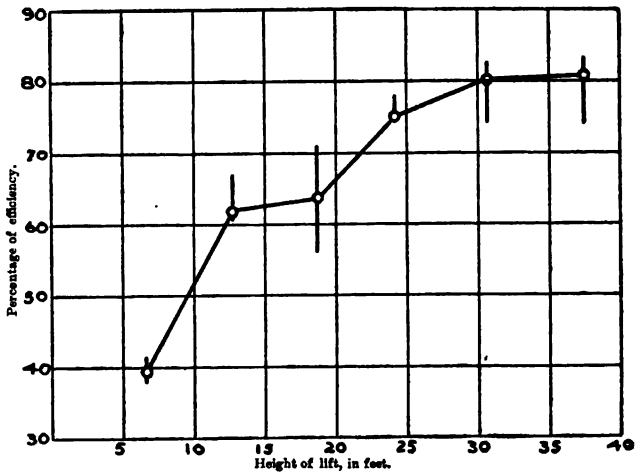


FIG. 30.—Variation of efficiency with varying height of lift of 4-inch Frizell pump at speed of 20 strokes per minute.

Discharges of 4-inch Frizell pump at various lifts and speeds; stroke, 23.7 inches.

Speed.	Discharge for 50 strokes; lift, 24.3 feet.	Discharge for 50 strokes; lift, 24.8 feet.	Discharge for 50 strokes; lift, 37.8 feet.	Discharge for 30 strokes; lift, 12.75 feet.	Discharge for 30 strokes; lift, 6.54 feet.	Plotted average discharge per stroke.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
10		451.5	462	275.5	274	9.168
10		457.5	465	275.5	274	
15	460	463.5	466	275.5	277	9.25
15		464	468	275.5	278.5	
20	465	464.5	467	278	281	9.309
20		464	468	278	281.5	
25	467	463.5	467	278.5	280	9.322
25		463.5	467.5	278.5	280	
30	466	469	467	279.5	279	9.334
30		465	467	279.5	280	
35	472	468	468	279.5	281	9.34
35		463.5	466.5	281	280.5	
40	467	466.5	466	281	284	9.42
40		466.5	467	280.5	280	
45	467	462.5	467.5	280.5	280	9.332
45		465	467.5	280	282	
50		449.5	443	277.5	279	9.254
50				279	279	
55				171	253	
55					267	

Figures from efficiency tests of 4-inch Frizell pump; stroke, 23.7 inches.

LIFT, 6.54 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	59.96	79.38	156.77	38.2	120	33
10	9.168	59.96	79.99	158.01	37.9	.....	.....
15	9.2502	60.56	79.15	156.33	38.7	.....	.....
15	9.2502	60.56	78.96	155.94	38.8	.....	.....
20	9.2724	60.64	84.31	161.51	36.4	135	9
20	9.2724	60.64	83.75	165.41	36.6	.....	.....
25	9.31	60.89	77.91	153.81	39.6	.....	.....
25	9.31	60.89	76.04	150.18	40.5	.....	.....
30	9.327	61.00	76.66	151.40	40.2	177	9
30	9.327	61.00	77.91	153.87	39.9	.....	.....
35	9.34	61.08	75.82	149.74	40.7	.....	.....
35	9.34	61.08	77.08	152.23	40.0	195	6
40	9.35	61.18	75.00	148.11	41.2	201	— 15
40	9.35	61.18	75.00	148.11	41.2	.....	.....
45	9.33	61.04	76.23	150.55	40.5	253.5	— 30
45	9.33	61.04	76.65	151.38	40.3	.....	.....
50	9.25	60.53	75.82	149.74	40.4	249	— 24
50	9.25	60.53	78.75	155.50	39.9	.....	.....
55	8.66	56.68	75.82	149.44	37.8	222	— 30
55	8.66	56.68	75.41	148.90	38.0	.....	.....

LIFT, 12.75 FEET.

10	9.168	116.89	89.63	177.00	66	.....	.....
10	9.168	116.89	87.07	171.97	68	.....	.....
15	9.260	118.05	94.90	187.43	63	.....	.....
15	9.260	118.05	98.20	193.11	61	.....	.....
20	9.270	118.22	97.17	191.91	61	.....	.....
20	9.270	118.22	95.77	189.24	62	.....	.....
25	9.310	118.70	97.22	192.00	62	175	30
25	9.310	118.70	96.60	190.78	62	.....	.....
30	9.327	118.91	94.63	186.88	63	.....	.....
30	9.327	118.91	97.90	184.82	63	.....	.....
35	9.340	119.08	95.22	188.09	63	.....	.....
35	9.340	119.08	96.45	190.78	63	250	11.5
40	9.350	119 17	109.85	216.95	54	.....	.....
40	9.350	119.17	100.70	198.88	59	.....	.....
45	9.330	118.99	99.57	196.66	60	325	— 11.5
45	9.330	118.99	101.40	200.26	59	.....	.....
50	9.250	117.99	95.77	189.24	62	350	— 95
50	9.250	117.99	96.90	191.54	62	.....	.....
55	5.700	72.67	99.30	196.11	37	375	— 75

LIFT, 18.8 FEET.

10	9.168	172.36	126.75	250.33	69	180	36
10	9.168	172.36	120.33	237.65	72	.....	.....
15	9.260	174.07	135.21	267.04	65	.....	.....
15	9.260	174.07	133.50	263.66	69	.....	.....
20	9.270	174.32	139.05	274.62	63	.....	.....
20	9.270	174.32	136.89	270.35	64	.....	.....
25	9.310	175.03	148.32	292.93	60	240	24
25	9.310	175.03	142.83	282.09	62	.....	.....
30	9.327	175.35	139.47	275.45	63	.....	.....
30	9.327	175.35	139.47	275.45	63	.....	.....
35	9.340	175.59	141.90	280.25	64	288	3
35	9.340	175.59	145.32	287.00	61	.....	.....
40	9.350	175.86	146.64	289.61	61	336	6
40	9.350	175.86	151.68	299.56	58	.....	.....
45	9.330	175.45	150.42	297.08	59	360	— 9
45	9.330	175.45	138.57	278.67	63	.....	.....
50	9.250	173.98	154.62	305.37	56	405	— 30
50	9.250	173.98	151.26	299.49	58	.....	.....
55	5.700	107.16	150.42	297.08	36	450	—120
55	5.700	107.16	156.32	308.75	34	.....	.....
58	5.430	102.14	159.72	315.36	32	450	—120
58	5.430	102.14	156.33	308.75	33	.....	.....

Figures from efficiency tests of 4-inch Frizell pump; stroke, 23.7 inches—Continued.

LIFT, 24.8 FEET.

Speed.	Discharge per stroke	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	227.36	149.28	294.82	77.1		
10	9.168	227.36	147.48	291.27	78.0		
15	9.260	229.65	161.28	377.69	72.3		
15	9.260	229.65	155.01	306.06	75.3		
20	9.270	229.89	155.82	307.74	74.7		
20	9.270	229.89	156.66	309.40	74.3		
25	9.310	230.89	156.66	309.40	74.6		
25	9.310	230.89	154.14	304.34	75.8		
30	9.327	231.11	154.14	304.32	75.8	348	— 36
30	9.327	231.11	152.46	301.10	76.7		
35	9.340	231.63	154.14	304.42	76.8		
35	9.340	231.63	162.48	319.23	72.5		
40	9.350	231.88	157.59	311.24	74.4	398	— 24
40	9.350	231.88	158.73	312.65	74.1		
45	9.330	231.38	161.10	319.00	72.5	471	— 36
45	9.330	231.38	158.73	312.65	74.0		
50	9.250	229.40	153.99	304.13	75.4		

LIFT, 30.75 FEET.

10+	9.168	280.89	176.45	348.50	80.5	250	15
10+	9.168	280.89	175.05	345.70	81.2		
10	9.168	280.89	176.00	347.80	80.7	240	40
10	9.168	280.89	167.60	331.00	84.8		
15	9.26	284.72	176.55	348.70	81.6		
15	9.26	284.72	176.55	348.70	81.6		
20	9.27	285.12	179.25	354.00	80.5	280	40
20	9.27	285.12	181.15	357.80	79.3		
25	9.31	286.29	180.65	356.80	80.2		
25	9.31	286.29	184.85	365.10	78.1		
30	9.327	286.81	180.15	355.80	80.6	370	0
30	9.327	286.81	177.35	350.30	81.8		
35	9.34	287.20	190.15	375.60	76.4	425	0
35	9.34	287.20	185.90	367.20	78.2		
40	9.35	287.65	197.45	390.00	73.7	490	— 25
40	9.35	287.65	198.60	392.20	73.3		
45	9.33	286.98	199.70	394.40	72.7	540	— 5
45	9.33	286.98	193.25	381.70	75.1		
50	9.25	284.58	188.70	372.70	76.3	590	—125

LIFT, 37.6 FEET.

10	9.168	344.61	208.32	411.35	83		
10	9.168	344.61	208.32	411.35	83		
15	9.26	348.14	213.30	421.26	82	275	50
15	9.26	348.14	211.56	417.84	83		
20	9.27	348.64	214.98	424.58	82		
20	9.27	348.64	220.74	435.93	80		
25	9.31	350.06	220.74	435.93	80	360	36
25	9.31	350.06	218.94	432.40	81		
30	9.327	350.70	224.16	442.70	79.4		
30	9.327	350.70	225.18	444.73	78		
35	9.34	351.18	224.34	443.07	79	410	0
35	9.34	351.18	231.00	456.22	77		
40	9.35	351.73	231.66	457.36	76		
48	9.33	350.91	229.56	453.38	77		
48	9.33	350.91	234.30	462.89	75		

This pump was arranged as a force pump, as shown in fig. 1 (p. 12), and tested at three different lifts, as shown in fig. 31. At a lift of about 24 feet the efficiency is seen to be reduced from about 75 per cent to about 52 per cent upon the addition of a stuffing box and two turns in the discharge pipe. This drop in the efficiency exhibits the harmful effect of added complications. The gland was carefully made, and as lightly packed as possible, to prevent leakage. Adding

this reduction of about 20 per cent to the efficiencies found for the two high lifts of 47 and 70 feet, respectively, the efficiency of the pump

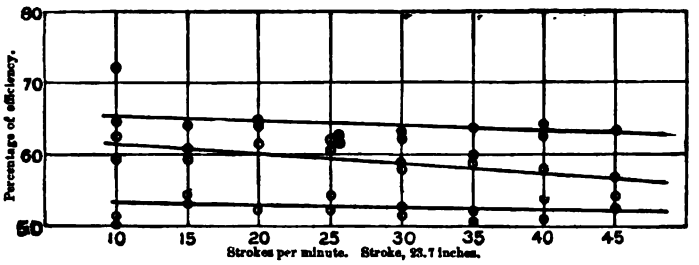


FIG. 31.—Efficiency of 4-inch pump used as a force pump.

when used as a simple lift pump, as in the first trials, is brought up to the neighborhood of 80 per cent.

Figures from efficiency tests of 4-inch Frizell pump, used as a force pump with a stuffing box; stroke, 23.7 inches.

LIFT, 24.3 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	222.48	221.08	436.68	51.2	280	24
10	9.168	222.48	225.52	445.40	50	.....	.....
15	9.260	225.02	223.32	441.06	53.2	.....	.....
15	9.260	225.02	218.88	432.28	54.4	.....	.....
20	9.270	225.26	217.76	430.07	52.3	.....	.....
20	9.270	225.26	218.88	432.28	52.1	.....	.....
25	9.310	226.32	211.08	416.88	54.2	308	—32
25	9.310	226.32	217.76	430.07	52.6	.....	.....
30	9.327	226.60	217.56	429.56	52	376	—32
30	9.327	226.60	216.60	427.78	52.9	.....	.....
35	9.340	227.12	221.08	436.63	52.1	.....	.....
35	9.340	227.12	220.96	448.56	50.6	.....	.....
40	9.350	229.55	217.68	449.08	51.1	.....	.....
40	9.350	229.55	215.44	425.47	53.9	.....	.....
45	9.330	224.69	215.44	425.47	52.8	520	—88
45	9.330	224.69	213.44	431.82	52.3	.....	.....

Frizell 4-inch pump; stroke, 23.7 inches; used as a force pump and delivering water against air pressure equivalent to the lift noted.

LIFT, 47.37 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	434.29	348.60	695.78	62.4	.....	.....
10	9.168	434.29	369.60	729.96	59.4	.....	.....
15	9.26	438.60	376.20	734.66	59.7	.....	.....
15	9.26	438.60	360.30	711.59	61.6	.....	.....
20	9.27	439.21	361.32	713.61	61.5	.....	.....
20	9.27	439.21	360	711	61.7	444	— 18
25	9.31	441.01	366.66	724.16	60.9	.....	.....
25	9.31	441.01	360	711	62	.....	.....
30	9.327	441.82	378.30	747.14	59.1	.....	.....
30	9.327	441.82	383.58	757.48	58.3	.....	.....
35	9.34	442.44	380.33	751.15	58.9	696	—108
35	9.34	442.44	380	750.50	58.9	.....	.....
40	9.35	442.90	385.44	761.23	58.1	.....	.....
40	9.35	442.90	385.32	761	58.2	.....	.....
45	9.33	441.96	402.24	794.34	56.9	756	— 90
45	9.33	441.96	413.32	816.30	54.1	.....	.....

Frizell 4-inch pump; stroke, 23.7 inches; used as a force pump and delivering water against air pressure equivalent to the lift noted—Continued.

LIFT, 70.5 FEET.

Speed.	Discharge per stroke..	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	646.34	495.75	895.77	72.1	.....	.....
10	9.168	646.34	510	1,007	64.5	.....	.....
15	9.26	652.83	515.33	1,101.11	59.2	.....	.....
15	9.26	652.83	514.50	1,016.22	64.2	.....	.....
20	9.27	653.54	508.35	1,003.90	65	.....	.....
20	9.27	653.54	513.22	1,013.62	64.4	.....	.....
25	9.31	656.36	536.25	1,059.09	61.9	.....	.....
25	9.31	656.36	534.15	1,054.96	62.2	.....	.....
30	9.327	657.55	532.13	1,050.96	62.5	.....	.....
30	9.327	657.55	527.85	1,042.50	63	.....	.....
35	9.34	658.47	521.53	1,030.02	63.8	780	— 75
35	9.34	658.47	515.33	1,101.11	59.8	.....	.....
40	9.35	659.18	532.13	1,050.96	62.7	.....	.....
40	9.35	659.18	516.66	1,020.32	64.6	825	—165
45	9.33	657.77	525.60	1,038.06	63.3	.....	.....
45	9.33	657.77	525.60	1,038.06	63.3	.....	.....

VAN VOORHIS PUMP.

Fig. 32 is a pump specially designed for slow speeds and low lifts, yet capable of running at high speeds. It is locally known in Kan-

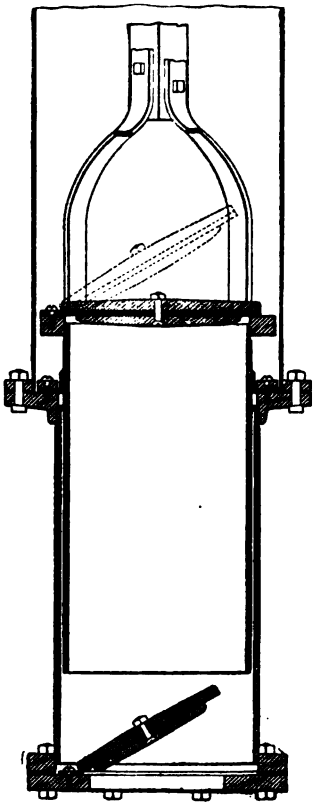


FIG. 32.—Vertical section of pump designed for slow speeds and low lifts.

sas as the Van Voorhis pump. The piston is replaced by a hollow plunger the upper opening of which is covered by a large clack valve. The plunger is packed with a suitable cup leather on the outside.

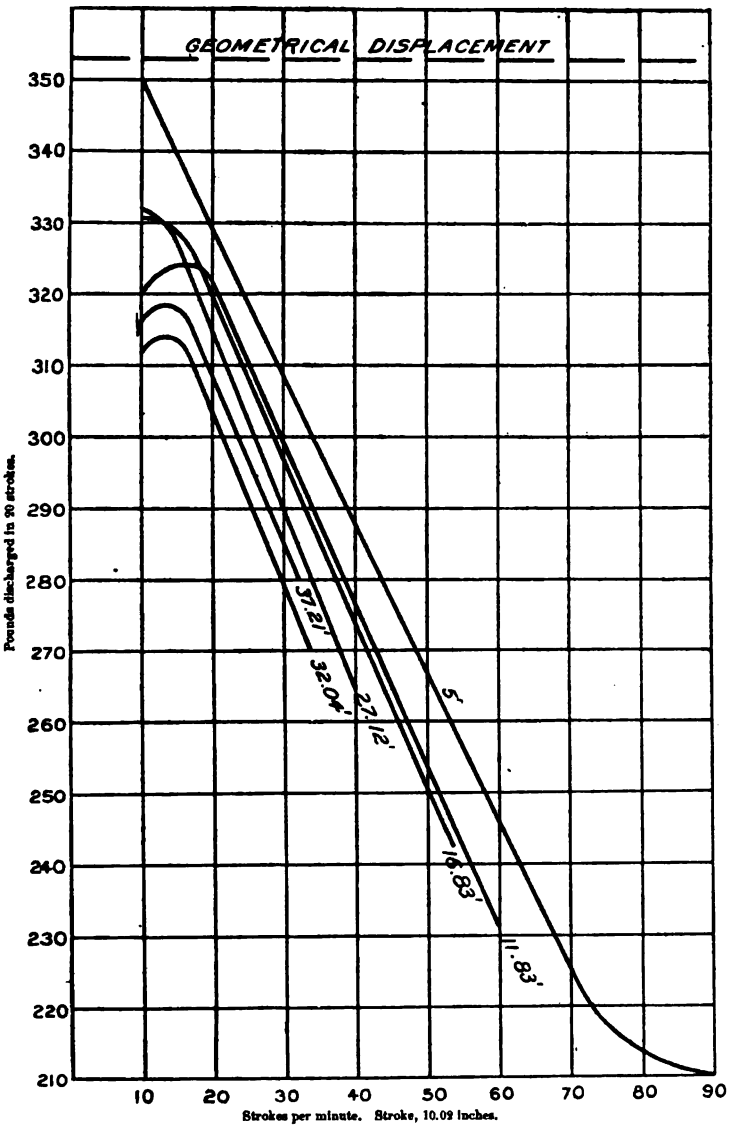


FIG. 33.—Varying-discharge curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed.

The suction valve also is a large clack valve. The valve area is very great, being 70 per cent for the lower valve and 94 per cent for the upper valve in an 8-inch pump. The weight of the pump was 146 pounds, and of the plunger, rod, etc., 101.5 pounds. This design has

many advantages for very slow running, which, however, quickly disappear when a moderate piston speed is reached. The discharge

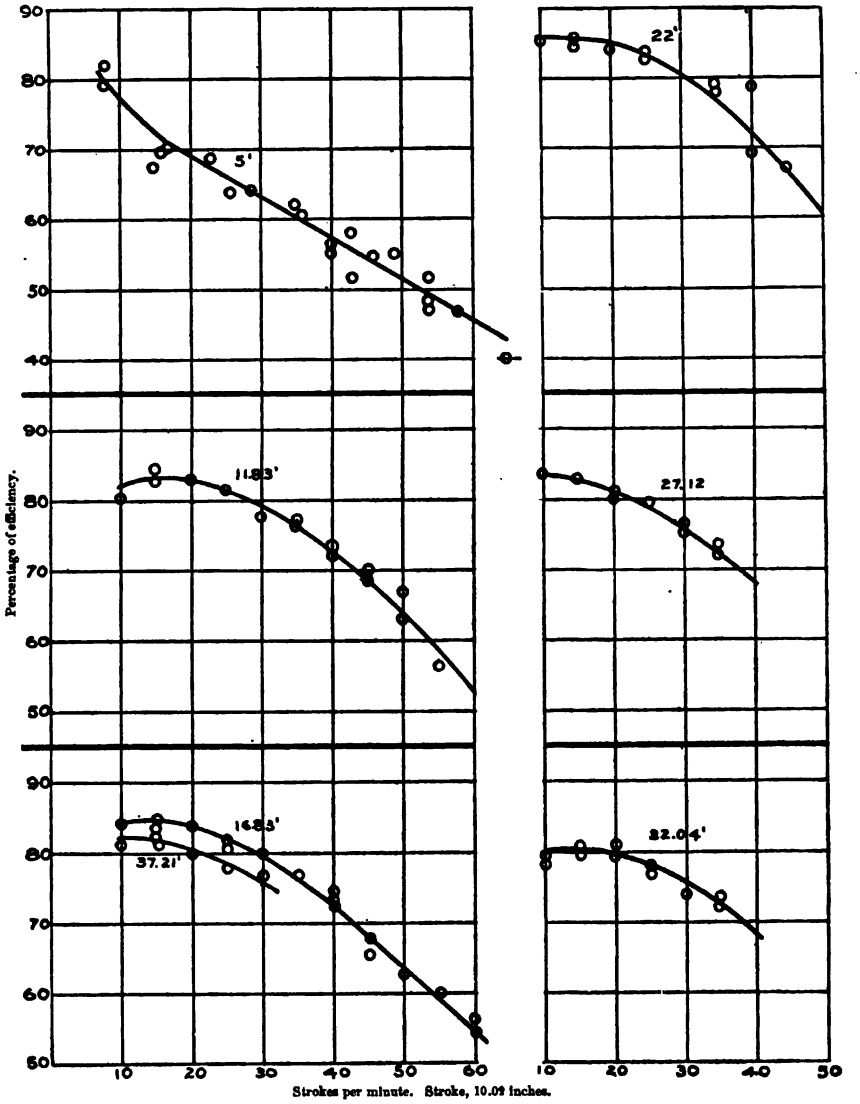


FIG. 34.—Varying-efficiency curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed.

curves, shown in fig. 33, and varying for each lift, give the results for the large valves. Fig. 34 shows the efficiencies for six different lifts, and fig. 35 the change of efficiency with increase of lift.

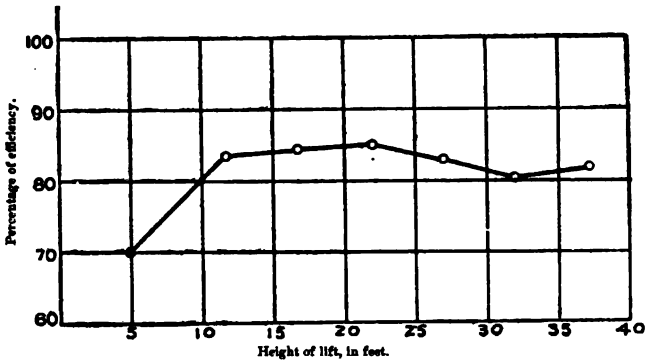


FIG. 35.—Variation of efficiency with varying height of lift of Van Voorhis pump at speed of 15 strokes per minute.

Discharge of Van Voorhis 8-inch pump at 5-foot lift; stroke, 10.02 inches.

Speed.	Discharge in 20 strokes.	Discharge in 20 strokes.	Plotted average; discharge per stroke.	Speed.	Discharge in 20 strokes.	Discharge in 20 strokes.	Plotted average; discharge per stroke
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
10	348.5	348.5	17.55	50	262	259.5	13.35
15	344.5	346	17.05	55	249	253	12.80
20	332	328	16.50	60	244	241.5	12.35
25	315	315.5	15.97	65	227	235	11.60
30	301	296	15.42	68	220	238	11.35
35	296	294	14.85	70	222	219.5	11.05
40	289	290	14.30	75	221.5	220	10.90
45	281	291	13.77	80	213	215	10.67
47	273		13.55	85	215.5	208.5	10.55

Discharge of Van Voorhis 8-inch pump at various lifts and speeds.

Speed.	Discharge, in pounds, for 20 strokes for lift:				
	11.83 feet.	16.83 feet.	27.12 feet.	32.04 feet.	37.21 feet.
10	320.5	328	331	306	316.5
10	318.5	332.5	332.5	308	315.5
15	323	329.5	329.5	313	319
15	325.5	328	326	317.5	318
20	326.5	320.5	317.5	298	309
20	322.5	321	315	302.5	309
25	309.5	306.5	300	293	299
25	308.5	310.5	300.5	290.5	296
30	294	297	288.5	290	290.5
30	301.5	301	296	282.5	288.5
35	290	284.5	285		
35	290.5	286	284		
40	275.5	256			
40	270.5	275			
45	272.5	243			
45	267.5	251			
50	257.5				
50	249.5				
55	247.5				
55	239				
60	232.5				
60	223.5				

Plotted average discharge per stroke.

Speed.	Discharge, in pounds, per stroke for lift:					
	11.83 feet.	16.83 feet.	22 feet.	27.12 feet.	32.04 feet.	37.21 feet.
10	15.975	16.525	16.562	16.6	15.55	15.8
15	16.1	16.45	16.412	16.375	15.7	15.225
20	16.05	16	15.887	15.775	15.2	15.45
25	15.575	15.425	15.275	15.125	14.575	14.85
30	15	14.85	14.675	14.5	14	14.25
35	14.425	14.3	14.1	13.9	13.35	----
40	13.85	13.725	13.487	13.25	----	----
45	13.275	13.175	12.912	12.65	----	----
50	12.7	12.6	12.3	12	----	----
55	12.125	12.05	----	----	----	----
60	11.55	11.5	----	----	----	----

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke, 10.02 inches.

LIFT, 4.875 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds work given to rod	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.	Stroke finished at closure of the upper valve.	Stroke finished at closure of the lower valve.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
8	17.65	86.04	130	108.55	79.20	235	+ 85	----	----
8	17.65	86.04	125.50	104.79	82.10	----	----	----	----
35	14.85	72.39	140.95	117.68	62	----	----	4	12
40	14.30	69.71	147.65	123.28	56	515	+ 20	5	16
40	14.30	69.71	151	126	55.30	----	----	5	16
54	12.80	62.40	158.30	132.18	47.20	780	— 50	11	21
54	12.80	62.40	156.65	131.03	47.40	----	----	11	21
54	12.80	62.40	155.30	129.67	48.20	----	----	11	21
54	12.80	62.40	157.70	131.69	47.80	675	— 35	11	21

LIFT, 5.166 FEET.

15	17.05	88.09	154.30	128.84	67.60	----	----	----	2
16	16.95	87.57	150.80	125.90	69.55	----	----	----	3
17	16.85	86.96	148.65	124.12	70	----	----	----	5
20	16.50	85.25	150	125.25	68	285	40	----	6
23	16.20	83.70	145.70	121.66	68.80	280	50	.6	6
26	15.85	81.89	153.30	128	63.97	----	----	.9	9
29	15.50	80.08	150	125.25	63.92	----	----	2	11
36	14.75	76.20	150	125.25	60.80	490	0	4	15
36	14.75	76.20	151.30	126.33	60.30	----	----	4	15
43	14	72.33	167.75	140.07	51.60	550	0	6	16
43+	13.90	71.81	147.65	123.28	58.20	----	----	6	17
46	13.65	70.52	154.30	128.67	54.80	575	15	7	19
43+	13.90	71.81	147.65	123.28	58.20	----	----	5	17
49	13.35	68.97	150	125.25	55	----	----	5	20
54	12.80	66.13	153.30	128	51.60	650	0	10	21
54	12.80	66.13	153.30	128	51.60	----	----	10	22
58	12.35	63.81	164.04	136.89	46.60	876	— 72	12	22
65	11.60	59.93	179.46	149.84	40	600	0	12	----
72	11.05	55.25	194.32	162.25	34	1,200	— 75	17	27
84	10.55	54.51	235.30	238.22	22.80	----	----	20	----
85	10.50	54.24	226.16	188.64	27.80	1,500	—150	21	37
90	10.40	53.73	264.12	220.37	24.70	1,200	—160	20	----
100	10	50	283.72	236.90	21.10	1,560	—135	22	----

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke, 10.02 inches—Continued.

LIFT, 11.83 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	15.975	188.9	281.1	235.8	80.5	417
10	15.975	188.9	281.1	235.8	80.5	422
15	16.1	190.4	276	230.2	82.7	427
15	16.1	190.4	269.9	225.4	84.5	437
20	16.05	189.8	274	228.8	82.9	475
20	16.05	189.8	273.7	228.5	83	500
25	15.575	184.3	272.5	226.9	81.2	525
30	15	177.4	272.4	227.4	78	660
30	15	177.4	266.2	222.3	79.8	720
35	14.425	170.6	264.6	221	77.2	750
35	14.425	170.6	266.9	222.9	76.5	780
40	13.85	163.8	272.2	227.3	72	1,060
40	13.85	163.8	266.9	222.8	73.5	895
45	13.275	157	274.5	229.2	68.5	1,070
45	13.275	157	268.4	224.1	70	1,015
50	12.7	150.2	269.1	224.7	66.8	1,135
50	12.7	150.2	285.4	238.2	63	1,265
55	12.125	143.4	303.9	253.7	56.5	1,410
55	12.125	143.4	303.9	253.7	56.5	1,380
60	11.55	136.6	308.5	257.6	53	1,357
60	11.55	136.6	303.2	259.5	52.6	1,432

LIFT, 16.83 FEET.

10	16.525	278.1	395.8	330.5	84.1	565
10	16.525	278.1	396.6	331.2	83.9	565
15	16.45	276.8	394.7	329.6	84.1	595
15	16.45	276.8	391.2	326.6	84.7	590
20	16	269.3	386.6	322.8	83.4	650
20	16	269.3	387.3	323.4	83.2	650
25	15.425	259.6	383.8	320.5	81	710
25	15.425	259.6	380	317.3	81.8	710
30	14.85	249.9	375.3	313.4	79.7	875
30	14.85	249.9	374.6	312.8	79.9	----------
35	14.3	240.6	374.2	312.5	77	940
35	14.3	240.6	373.5	311.9	77.1	1,000
40	13.725	231	370.4	309.3	74.7	1,030
40	13.725	231	375.3	313.4	73.7	1,050
40	13.725	231	372.3	310.9	74.3	1,070
40	13.725	231	374.2	317.8	72.7	1,010
45	13.175	221.7	391	326.5	67.9	1,224
45	13.175	221.7	405.9	338.9	65.4	1,309
50	12.6	212	404.8	338	62.7	1,245
50	12.6	212	405.9	338.9	62.5	1,395
55	12.05	202.8	404.7	337.9	60	1,372
55	12.05	202.8	404.7	337.9	60	1,330
60	11.5	193.5	426.4	356.1	54.3	1,515
60	11.5	193.5	410.4	342.7	56.4	1,447

LIFT, 22 FEET.

10	16.562	364.3	510.8	426.5	85.4	720
10	16.562	364.3	510.1	425.9	85.5	715
15	16.412	361	504.7	421.4	85.6	770
15	16.412	361	510.8	426.5	84.6	740
20	15.887	349.5	497.7	415.6	84.1	855
20	15.887	349.5	492.2	411	85	890
25	15.275	336	486.8	406.5	82.6	945
25	15.275	336	480.7	401.4	83.7	----------
30	14.675	322.8	483.9	404	79.9	1,035
30	14.675	322.8	482.2	402.7	80.1	1,140
35	14.1	310.2	474.6	396.3	78.2	1,215
35	14.1	310.2	468.4	391.2	79.3	1,160
40	13.487	296.7	501.5	418.8	70.8	1,380
40	13.487	296.7	513.8	429	69.1	1,507
45	12.912	284	505.3	421.9	67.3	1,402
45	12.912	284	505.3	421.9	67.3	1,402
50	12.3	270.6	531.6	443.9	60.9	1,687
50	12.3	270.6	533.2	445.3	60.7	1,650

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke 10.02 inches—Continued.

LIFT, 27.12 FEET.

Speed.	Discharge per stroke.	Foot pounds of useful work.	Average pull on rod.	Foot pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	16.6	450.2	646.8	539.7	83.4	832
10	16.6	450.2	646.5	539.8	83.4	900
15	16.375	444.1	642.5	536.5	82.7	969
15	16.375	444.1	640.9	535.1	83	975
20	15.775	427.8	634.7	530	80.7	1,027
20	15.775	427.8	638.2	532.9	80.2	1,035
25	15.125	410.2	617.3	515.4	79.5	1,207
25	15.125	410.2	619.9	517.7	79.2	1,170
30	14.5	393.2	619.9	517.7	75.96	1,395
30	14.5	393.2	615.7	514.1	76.4	1,380
35	13.9	387	611.5	510.6	71.8	1,500
35	13.9	387	600	501	73.2	1,447

LIFT, 32.04 FEET.

10	15.55	498.2	760.4	634.9	78.4	1,057
10	15.55	498.2	760.4	634.9	78.4	1,080
15	15.7	503	753.5	629.2	79.9	1,132
15	15.7	503	746.5	623.3	80.7	1,110
20	15.2	487	734.9	613.6	79.3	1,252
20	15.2	487	721	602	80.9	1,350
25	14.575	467	725.6	605.9	77	1,320
25	14.575	467	718.9	600.2	77.8	1,440
30	14	448.5	724.5	604.9	74.1	1,455
30	14	448.5	712.1	594.5	75.4	1,447
35	13.35	427.7	706.2	589.6	72.5	1,567
35	13.35	427.7	696.3	581.4	73.5	1,567

LIFT, 37.21 FEET.

10	15.8	587.9	868	724.8	81.1	1,177
10	15.8	587.9	865.7	722.8	81.3	1,177
15	15.925	592.5	867.2	724.1	81.8	1,185
15	15.925	592.5	864.5	721.8	82	1,185
20	15.45	574.9	857.3	715.9	80.3	1,230
20	15.45	574.9	859.1	717.3	80.1	1,280
25	14.85	552.5	845.5	704.5	78.2	1,305
25	14.85	552.5	847.8	707.9	78	1,380
30	14.25	530.2	825.7	689.5	76.9	1,380
30	14.25	530.2	828.1	687.3	77.1	1,380

COOK PUMP.

The Cook cylinder, made by the Cook Well Company, of St. Louis, Missouri, has been developed especially for deep-well pumping, and the 4-inch size is shown in fig. 36. The design admits of the withdrawal of both the piston and the suction-valve device for inspection or repair. The actual diameter is 3.75 inches. Though furnished with double packing leathers and having a valve area of 21 per cent of the cylinder area, its efficiency in deep wells is notable. Both valves are rubber disks, guided by a central stem. The cylinder is brass lined and highly polished, and friction is thus greatly reduced. However, on account of the high pressures with which this pump deals, double cup leathers for packing are required, by which, on the other hand, friction is increased. Built especially for high lifts, it is not to

be expected that it will develop a high efficiency at the low lifts prevailing in irrigation work.

In testing this pump it was first operated in an open well with a 34.8-foot lift. The efficiency varied from about 78 to 58 per cent at

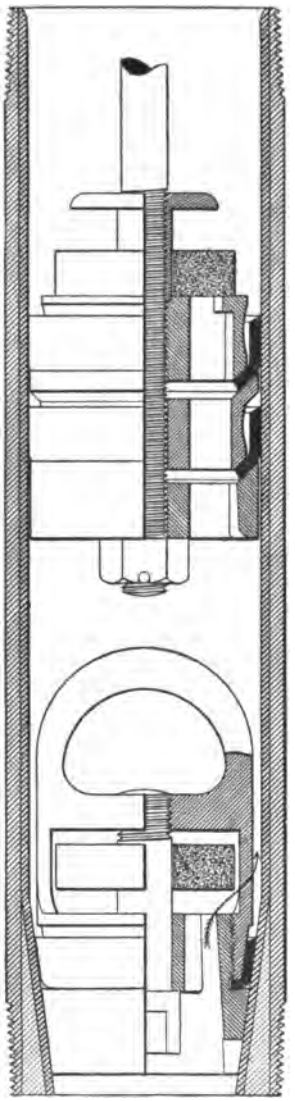


FIG. 36.—Vertical section of Cook cylinder.

speeds of 12 to 40 2-foot strokes per minute. The pump was then provided with a stuffing box, carefully made and packed, and was made to deliver water against an air pressure equivalent to the previous total lift of 34.8 feet.

The mean pull on the pump rod was found to be increased about 30 pounds by the friction in the stuffing box, and the efficiency, in

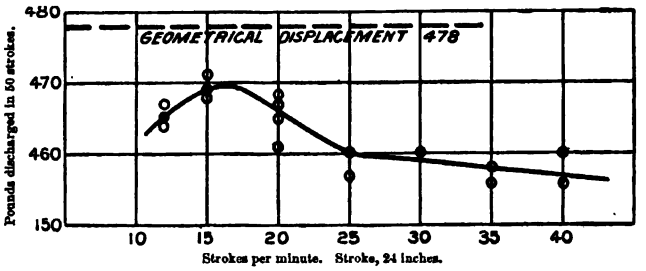


FIG. 37.—Discharge curve for 4-inch Cook deep-well pump.

consequence, lowered from the 78 to 58 per cent of the previous test to 67 to 53 per cent. At the higher lifts tried the same method was

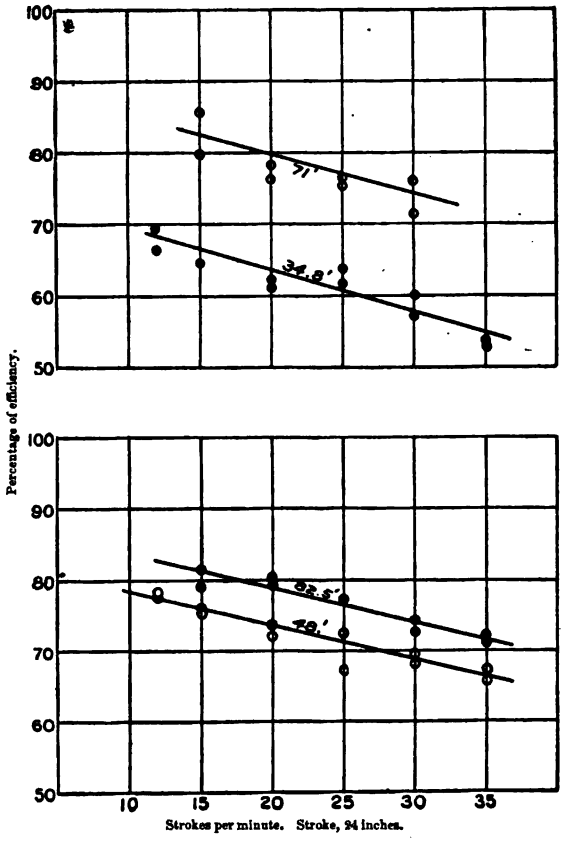


FIG. 38.—Varying-efficiency curves of 4-inch Cook pump, showing effect of varying lift and speed.

followed, and the efficiency, at an 82.5-foot lift and at speeds ranging from 15 to 35 strokes per minute, was found to range from 81 to 72

per cent. Allowing for the increase of friction resulting from the addition of a stuffing box, the efficiency of the pump in an open well and at the same depth would probably be 85 to 77 per cent. Fig. 37 gives the discharge curve, and fig. 38 the efficiency curves, at differing lifts, for this pump, fitted with the packed stuffing box and rod. There are exhibited a quick action of the valves, a remarkably low maximum stress, and slight compression in the pump rod at speeds above 20 strokes per minute.

There is here seen to be marked advantage in the special adaptation of parts to special conditions.

Discharge of 4-inch Cook pump; stroke, 24 inches.

Speed.	Experimental discharge per 50 strokes.	Plotted average discharge per stroke.	Speed.	Experimental discharge per 50 strokes.	Plotted average discharge per stroke.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
12	465	9.3	20	465	
12	464		25	457	9.2
12	467		25	460	
15	469	9.38	30	460	9.18
15	471		30	460	
15	468		35	458	9.16
15	468		35	456	
20	468	9.32	40	456	9.14
20	461		40	460	
20	467				

Figures from efficiency tests of 4-inch Cook pump; stroke, 24 inches.

LIFT, 34.8 FEET; OPEN WELL.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
12	9.3	323.6	207.6	415.6	77.8	280
12	9.3	323.6	213.9	428.1	75.6	285
15	9.38	326.4	205.3	410.9	79.4	315
15	9.38	326.4	203.9	408.2	79.9	305
20	9.32	324.3	215.9	432.1	75	350
20	9.32	324.3	212.5	425.4	76.2	335
25	9.2	320.1	225.6	451.6	70.8	385
25	9.2	320.1	225.6	451.6	70.8	410
30	9.18	319.5	246.3	493	64.8	510
30	9.18	319.5	243.1	486.6	65.6	525
35	9.16	318.8	257.6	515.6	61.8	575
35	9.16	318.8	253.4	507.3	62.8	635
40	9.14	318.1	273	546.4	58.2	650
40	9.14	318.1	270.1	540.7	58.8	650

LIFT, 34.8 FEET, USING STUFFING BOX.

12	9.3	323.6	243.1	486.5	66.5	315
12	9.3	323.6	232.7	465.7	69.5	310
15	9.38	326.4	251.4	503.2	64.8	350
15	9.38	326.4	251.4	503.2	64.8	375
20	9.32	324.3	264.5	529	61.2	400
20	9.32	324.3	260.4	521.3	62.2	415
25	9.2	320.1	250	500.4	63.9	420
25	9.2	320.1	259.1	518.6	61.7	435
30	9.18	319.5	266.7	533.8	59.8	565
30	9.18	319.5	279.2	558.8	57.1	560
35	9.16	318.8	297.2	594.9	53.5	650
35	9.16	318.8	300	600.4	53	675

Figures from efficiency tests of 4-inch Cook pump; stroke, 24 inches—Continued.

LIFT, 48 FEET, USING STUFFING BOX.

Speed.	Discharge per stroke.	Foot pounds of useful work.	Average pull on rod.	Foot pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
12	9.3	446.4	284.8	570.1	78.3	380
12	9.3	446.4	288.1	576.7	77.4	375
15	9.38	450.2	295.4	591.2	76.1	400
15	9.38	450.2	298.6	597.7	75.3	415
20	9.32	447.4	302.2	605	73.9	460
20	9.32	447.4	309.2	618 9	72.3	450
25	9.2	441.6	327.3	655.1	67.4	515
25	9.2	441.6	304.9	610.2	72.3	490
30	9.18	440.6	322.7	645.9	68.2	565
30	9.18	440.6	316.2	632.8	69.6	545
35	9.16	439.7	325.7	651.9	67.4	640
35	9.16	439.7	331.9	664.4	66.1	655

LIFT, 71 FEET, USING STUFFING BOX.

15	9.38	666	416.6	834	79.8	565
15	9.38	666	389.3	779.2	85.4	520
20	9.32	661.7	433.9	868.4	76.2	585
20	9.32	661.7	421.4	843.4	78.4	595
25	9.2	653.2	431.3	863.2	75.6	625
25	9.2	653.2	428.1	856.8	76.2	630
30	9.18	651.8	429	858.6	75.9	750
30	9.18	651.8	454.7	910.2	71.6	765

LIFT, 82.5 FEET, USING STUFFING BOX.

15	9.38	773.9	475	950.7	81.4	590
15	9.38	773.9	488.2	977.1	79.2	590
20	9.32	705	478.5	957.7	80.3	705
20	9.32	705	485.3	971.5	79.1	700
25	9.2	759	489.6	980	77.4	780
25	9.2	759	488.9	978.5	77.5	825
30	9.18	757.3	502.7	1,020	74.2	830
30	9.18	757.3	518.7	1,038	72.9	840
35	9.16	755.7	529.2	1,059	71.3	815
35	9.16	755.7	523.7	1,048	72.1	1,020

SUMMARY.

To pump large quantities of water with small power economically, it is necessary that the pump speed be slow, preferably below 20 strokes per minute; that the pump itself be large and of long stroke, and that the valve area be at least 30 per cent of the cylinder cross-section area.

For the more rapid-running pumps the valve area should be still larger.

The efficiency of pumps rightly called good pumps may vary from 20 to 85 per cent, depending on the lift and the piston speed.

A fall of 25 per cent in the efficiency of a pump in the usual range of windmill speed is not uncommon.

A pump having a variation of only 5 per cent is possible.

For wells about 20 feet deep there is no need for using a pump of less than 75 per cent efficiency for average speeds.

Two pumps may compare very favorably at a certain lift, and much less favorably at some other lift not greatly different.

A pump having an efficiency of over 80 per cent at piston speeds up to 100 feet per minute is possible at a 20-foot lift.

Some pumps can be run at a piston speed of 180 feet per minute and maintain an efficiency above 70 per cent for lifts above 20 feet.

A pump with very large clack valves, on a very low lift, may give an efficiency from 80 per cent at slow speed to 50 per cent at a piston speed of 80 feet per minute.

Pumps at slow speed and at high speed alike discharge a little less water per stroke than at medium speed—perhaps from 1 to 2 per cent.

A pump with small delivery pipe may at high speed deliver a considerably larger amount of water than that computed from the cylinder capacity.

With pumps having an ample supply of water the speed may be limited by failure of the lower valve if its movement is not limited.

Valves of limited movement are preferable for fast speeds.

The addition of a stuffing box to any form of pump may seriously reduce the efficiency.

The initial stress on the upstroke at the higher speeds is the destructive element in windmill operation. The use of a device for reducing this stress is well worth consideration. At piston speeds of only 70 feet per minute this sudden jerk may be equivalent to two or three times the weight of the column of water lifted.

A method of pump testing is possible which would determine the behavior of valves and give the measure of the resistances at various stages of the stroke in such manner as to admit of quantitative statement.

RESISTANCE TO ROTATION OFFERED BY VARIOUS CRANK-DRIVEN PUMPS.

The resistance offered to any driving mechanism by a single-cylinder pump varies greatly at different stages of the pump stroke. If connection with the pump be through the usual crank, the resistance offered by the crank will be slight at each dead center. Piston and rod, if of sufficient weight, will afford some motive power on the downstroke. The useful work is done during the upstroke, and the larger portion of it during the first part of the upstroke, excepting when the speed is very slow. In fig. 39 horizontal distances represent positions of the crank in its circular course during a single revolution. The position in each case is located from the lower dead center as an initial point. The heights of the vertical lines represent the resisting moment at that point. Neglecting the effect of angularity of the connecting rod, the smooth sinusoidal curve represents the resistances to turning, assuming the load to be uniform on the upstroke and to be diminished to about one-eighth on the downstroke. This diminished load is the weight of the piston, rod, etc. The shaded area above

the zero line represents the work done in raising the piston, rod, and water; and that below the line, from 180° to 360°, represents the work returned by the falling piston and rod on the downstroke. The outside line and the heavier-shaded portion show the actual resisting moments, as computed from the diagram, fig. 40, from the work of an 8-inch pump at a lift of 22 feet and a speed of 25 strokes per minute. The additional work required for acceleration of the water, etc.,

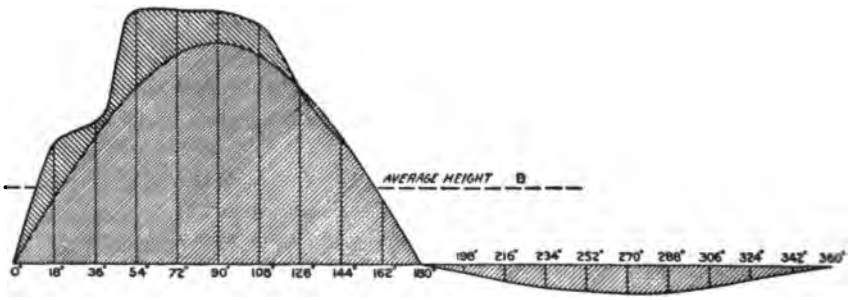


FIG. 39.—Diagram of resistance to rotation of crank driving a single-cylinder lift pump.

is shown by the heavier-shaded area. This great variation in the turning resistance renders it impossible, without considerable loss of efficiency, effectively to use certain forms of motors.

If a horse be used to operate a pump of this kind, by means of a sweep or other suitable turning device, during a stroke of the pump, he will meet with resistances such as shown by the vertical lines in fig. 39. The pump must not be so large that the maximum moment

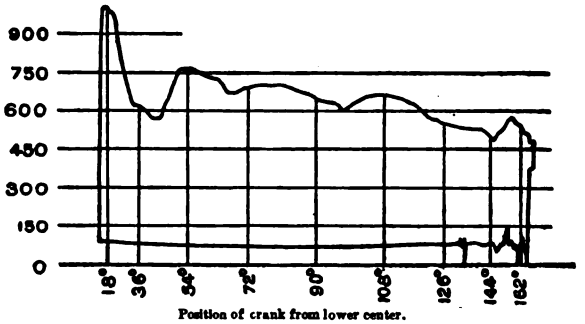


FIG. 40.—Dynamometer diagram of actual resistance at various positions of crank.

can not be reached and overcome at a point somewhere between 50° and 90° of the revolution. Even then, for at least half the time, the horse will be doing no work at all, and for 60 per cent of the time he will be loaded below the average. The line AB gives the average resistance. Furthermore, it appears that the maximum load reaches to more than three and one-half times that of the average load. This fault may be remedied in part by the use of a fly wheel of moderate

weight. The unevenness of loading will continue to be so considerable, however, as to render the work of the horse laborious; whereas with equalized load he could do even a larger amount of work with comparative ease. A windmill encounters the same difficulty, as may be seen from the ineffectual efforts it makes in light winds to pass

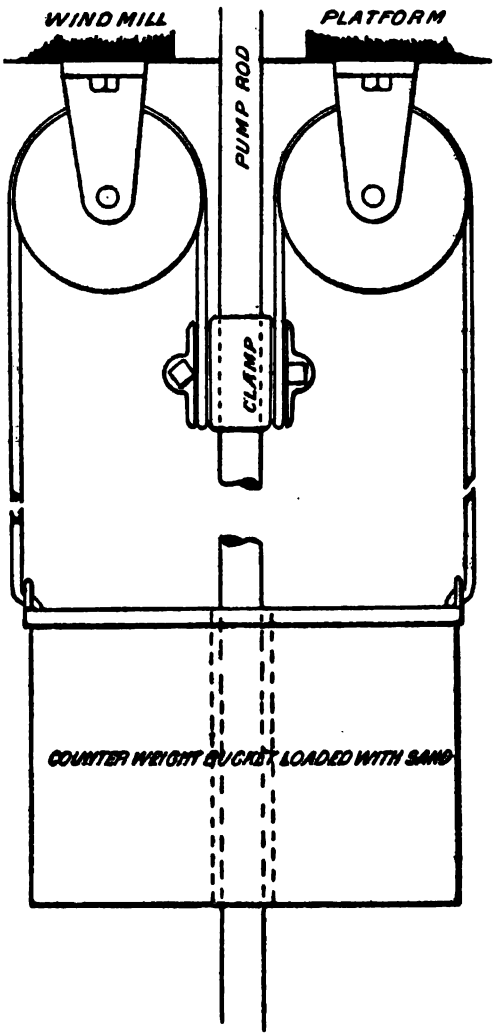


FIG. 41.—Method of counterbalancing a windmill pump.

this point of maximum load. It becomes apparent, too, that if the load were evenly distributed the mill would find the light wind power sufficient for light running. By the use of a counterweight a partial distribution at least can be effected.

A modification of the horse-power sweep sometimes to be seen is a wooden spring bar so attached as to offer a spring resistance during

the light-pull interval and to assist correspondingly on the heavy pull. It has decided merit. As applied to the pump rod of a windmill the modification might take the form of a weight encircling the rod and given a direction of motion opposite to that of the rod by means of pulleys, as shown in fig. 41. This device should be attached to back-geared mills only, and should have its range of action fixed so high in the tower as to leave the pump rod free to act in compression without bending. The counterweight should equal one-half that of the load on the piston and should range as low in the tower as practicable.

Differential pumps equalize the work between the upstroke and

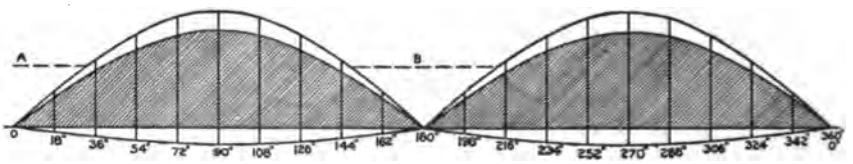


FIG. 42.—Diagram of resistance to rotation of a shaft carrying two cranks driving a duplex pump.

the downstroke by employing a very large piston rod. If the cross-section area of the piston rod be one-half that of the cylinder, one-half of the cylinder capacity will be discharged on the upstroke and the remaining half by displacement on the downstroke. Work is thus equalized between the upstroke and the downstroke. Since, however, the work required on the downstroke, which has now become in fact a down thrust, necessitates the use of stiff rods in order to avoid compressive bending, there is disadvantage in the practice where long rods are required, as in deep wells or for windmills with

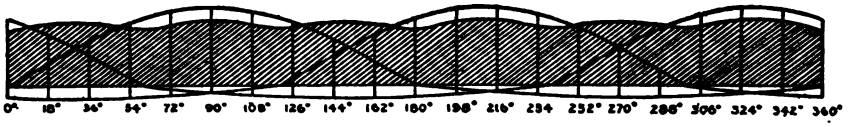


FIG. 43.—Diagram of resistance to rotation of a shaft carrying three cranks driving a triplex pump.

high towers. For such long thrust rods guides must be provided at frequent intervals to preserve the alignment and insure direct action, and frictional resistance is thus introduced.

Again, there will be enlargement of the pump rod for a short distance only at the water surface in the discharge pipe. This enlargement is partially withdrawn from the water on the upstroke, thereby vacating a space to be filled and thus reducing the discharge, and it is lowered into the water on the downstroke, thereby forcing upward an equal volume of water by displacement and thus compensating for the previous loss. Yet it does not effect an equalization of work

between the two strokes. The full cylinder capacity is lifted on the upstroke nearly to the full height of the discharge, and on the downstroke but half of this is displaced from the height of the discharge opening, requiring little work on the downstroke. It is evidently a mistake to regard this device as an equalizer of work. The enlargement, to be fully effective, should continue down to the piston.

Compound pumps having four valves and discharging on both the upstroke and the downstroke, or two cylinder pumps in which one cylinder makes an upstroke during the downstroke of the other, would produce a resistance diagram such as shown in fig. 42. This diagram

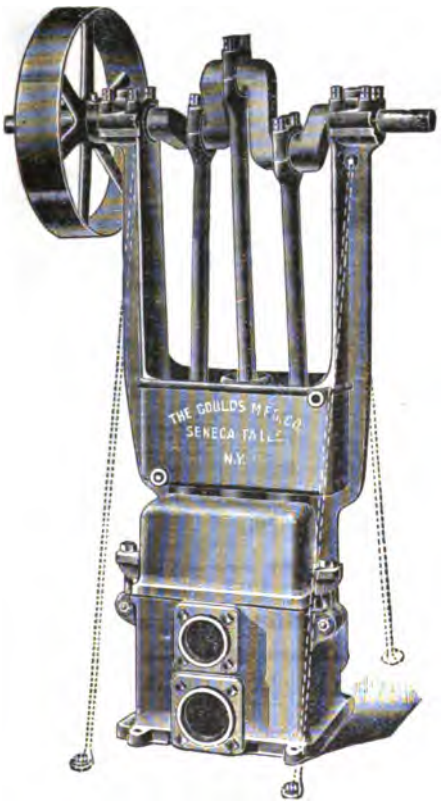


FIG. 44.—Gould triplex power pump.

represents the crank resistance of a pump discharging the same quantity of water per revolution of the crank as the pump represented in fig. 39 (p. 66). The curve below the zero line exhibits the effect of the weight of piston and rod, and the curve above the resistance due to lifting piston, rod, and water. The shaded portions show the resistances at each point in the revolution, the piston weights balancing each other. In this double-cylinder form the maximum resistance is about 1.6 times the average resistance, as against $3\frac{1}{2}$ times with the

single-cylinder form. At two points in each rotation the resistance will be zero, but it does not fall below zero, as with the single-cylinder form. A pump of this kind can be more easily driven by horse power than one with a single cylinder, but it is, on the other hand,

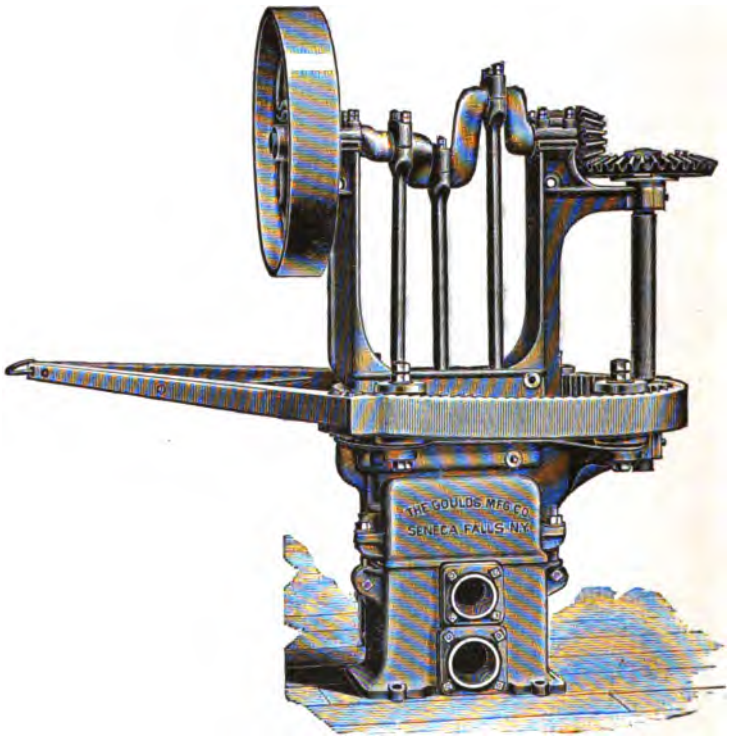


FIG. 45.—Gould triplex pump and horsepower combined.

too irregular in action to admit of any considerable speed. With a single large cylinder counterweighed as above described the resistances are as shown in fig. 42 (p. 68) and the efficiency is greater than with two small cylinders.

Fig. 43 (p. 68) shows the resistances in a three-cylinder pump arranged to discharge the same quantity per revolution as did the

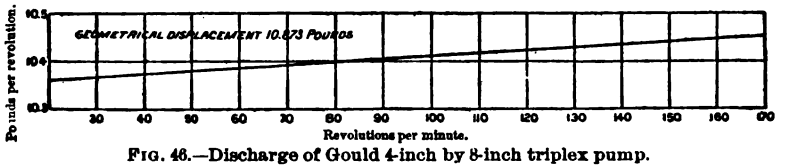


FIG. 46.—Discharge of Gould 4-inch by 8-inch triplex pump.

two-cylinder and the one-cylinder forms. The three pistons are driven from three crank elbows in the shaft set at 120° each to each, as shown in fig. 44 (p. 69). The resistance offered by this

device is very uniform, as appears from the shaded portion of the diagram. The maximum resistance is but 6 per cent above the average resistance, and a moderate fly wheel renders the motion entirely steady.

Such pumps admit of the best use of any constant power, as that of a horse or a small engine. In Gould's triplex pump (fig. 44), a horse will encounter a nearly uniform resistance and can work to the best advantage. A 4 by 8 inch pump of this make was tested by the

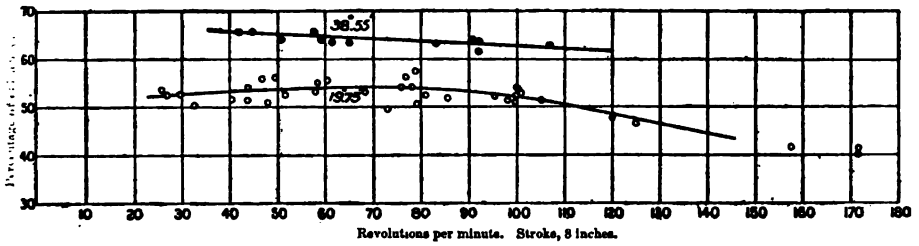


FIG. 47.—Varying-efficiency curves of Gould triplex pump, showing effect of varying speed, and at two different lifts.

author at three different lifts. The crank shaft is arranged to be run by a pulley belted from any source of power, or by means of the encircling internal master wheel and the vertical shaft carrying bevel gears, as in fig. 45, and operated by means of a horse attached to a sweep on the master wheel. The very uniform resistance of this kind of pump, as shown by the diagram, fig. 48, which represents the belt pull or resistance while at work, has opened a large field for it

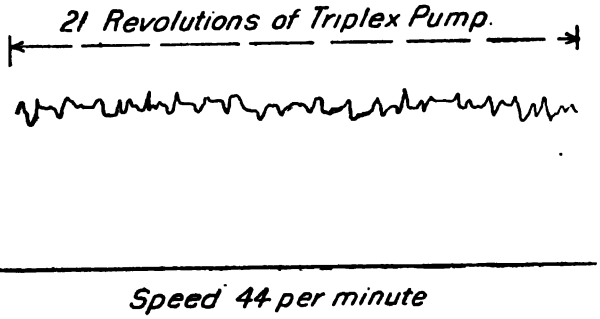


FIG. 48.—Dynamometer diagram showing uniformity of resistance afforded by triplex pump.

in connection with various motors. While not so efficient as a single-cylinder pump of equal capacity, yet it applies energy so effectively as to render it the more advantageous form for many uses. The efficiency of the one tested is seen to be about 60 per cent—not greater than that of many homemade water lifts. Its durability and compactness, however, entitle it to very favorable consideration in comparison with any such homemade device.

Discharges of Gould triplex pump.

LIFT, 19.75 FEET.

Speed, in revolutions per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per revolution.	Speed, in revolutions per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per revolution.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
30	331	308	10.2	75	784	783	10.4
30	321	308	10.2	79	816	825	10.4
36	353	373	10.3	82	876	857	10.4
47	476	490	10.4	90	947	941	10.4
52	539	542	10.4	99	1,035	1,035	10.4
56	581	583	10.4	111	1,175	1,161	10.4
57	644	595	10.4	114	1,208	1,192	10.4
60	628	625	10.4	114	1,213	1,192	10.4
65	672	678	10.4	133	1,390	1,390	10.4
70	728	730	10.4	156	1,630	1,631	10.4
74	771	772	10.4	166.8	1,720	1,745	10.4

LIFT, 38.55 FEET.

40	416	416	10.4	84	898	853	10.4
45	482	468	10.4	90	964	941	10.4
77	827	803	10.4				

Figures from efficiency test of Gould triplex pump 4 by 8 inches.

LIFT, 19.75 FEET.

Speed, in revolutions per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to pump per minute.	Mechanical efficiency.
	Pounds.			*Per cent.*
25.9	265	5,234	9,715	53.8
27	276	5,451	10,370	52.5
29.5	303	5,984	11,429	52.3
32.8	338	6,675	13,283	50.2
40.5	420	8,295	16,008	51.8
43.8	455	8,986	17,569	51.1
43.8	455	8,986	16,588	54.1
46.9	487	9,618	17,213	55.8
48	500	9,875	19,405	50.9
49.6	515	10,171	18,133	56.1
51.8	540	10,665	20,280	52.6
58.2	607	11,988	22,410	53.5
58.8	612	12,087	21,952	55
60.6	639	12,620	22,771	55.4
68.2	712	14,062	26,391	53.2
73.2	764	15,086	30,330	49.7
76	794	15,681	29,063	53.9
78.2	815	16,096	29,809	54
79.2	825	16,292	33,309	48.9
81.1	848	16,748	32,072	52.2
85.7	895	17,668	35,743	51.8
95.3	997	19,690	37,750	52.1
98.3	1,026	20,263	39,710	51
100	1,047	20,678	40,175	51.4
100	1,047	20,678	40,413	51.1
101	1,055	20,836	39,430	52.8
105.3	1,100	21,725	42,409	51.2
120	1,255	24,786	51,698	47.9
125	1,305	25,773	55,202	46.7
157.9	1,650	32,587	78,199	41.6
171.4	1,790	35,352	86,142	41
171.4	1,790	35,352	87,987	40.2

Figures from efficiency test of Gould triplex pump 4 by 8 inches—Continued.

LIFT, 38.55 FEET.

Speed, in revolutions per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to pump per minute.	Mechanical efficiency.
	Pounds.			*Per cent.*
42.1	439	16,923	25,801	65.6
44.8	465	17,925	27,167	65.9
50.8	530	20,431	31,765	64.3
57.7	600	23,130	35,144	65.8
59.4	618	23,824	37,177	64
61.2	640	24,672	39,027	63.2
65.2	675	26,022	41,058	63.3
83.3	870	33,538	52,978	63.3
90.9	950	36,622	57,212	64
92.3	965	37,201	58,517	63.5
92.3	965	37,201	60,065	61.9
107.1	1,120	43,176	69,324	62.2

VARIOUS WATER LIFTS.

On the Western plains devices for raising water other than the reciprocating pumps are not common. The centrifugal pump, which, if driven at a high and uniform speed, has an efficiency of about 66 per cent at a lift of about 16 feet, has its field limited to tracts where water is to be found at comparatively shallow depths and to applications where motive power giving uniform and high speed may be economically employed. It is not well adapted to horse or windmill power.

Early forms of water lifts are mentioned and illustrated by Weisbach. While these are of interest, they are not likely to be used by American farmers, who are impatient of slow and laborious methods. The following statements are abstracted from Mechanics of Pumping Machinery, by Weisbach and Hermann:

Men, bailing with buckets holding about one-third of a cubic foot each, can lift 15 buckets per minute, 3 to 4 feet high, for a length of time daily equivalent to six hours of steady labor. This amounts to about 390,000 foot-pounds per day, or a quantity of water sufficient to cover an acre one-half inch deep. With deeper wells the sweep or weighted lever will yield about the same result in foot-pounds daily per man. At a crank handle an ordinary laborer can exert a force of 15 pounds in steady work, or can labor steadily at a rate of approximately 3,300 foot-pounds per minute. This is about the best manner of employing human labor. From a 10-foot well a man with a winch and bucket, properly proportioned, can cover an acre with one-half inch of water in a day. Approximately the same can be done with a hand pump suitably proportioned to the lift. The Dutch scoop, which consists of a long-handled scoop shovel suspended from an overhead support by a rope and swung by three men, will lift water 3½ feet and throw it 6½ feet horizontally. One man working thus alone can do

about as much work as by the bailing method, but three men working together on a single scoop will do more than five men bailing separately.

BUCKET LIFTS.

A very old device for raising water consists of a vertical rope or chain carrying buckets, the chain running on a power-driven sprocket wheel at the top and maintained in proper position by a loose sprocket suspended in its lower loop. The modern development of the sprocket wheel and of the cast-link belt, in which links may be had specially adapted to receive sheet-metal buckets, has brought the bucket lift

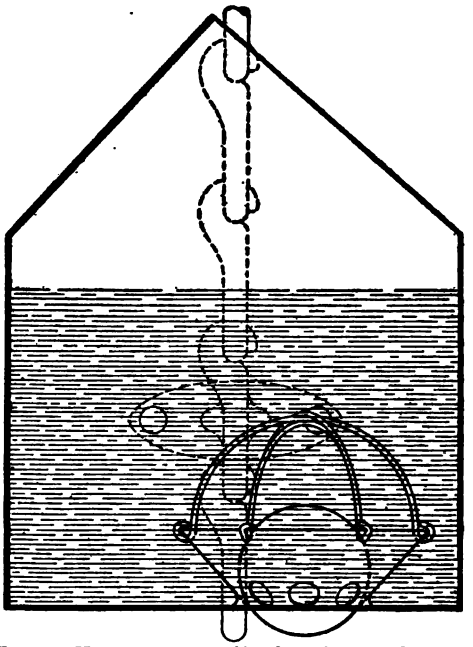
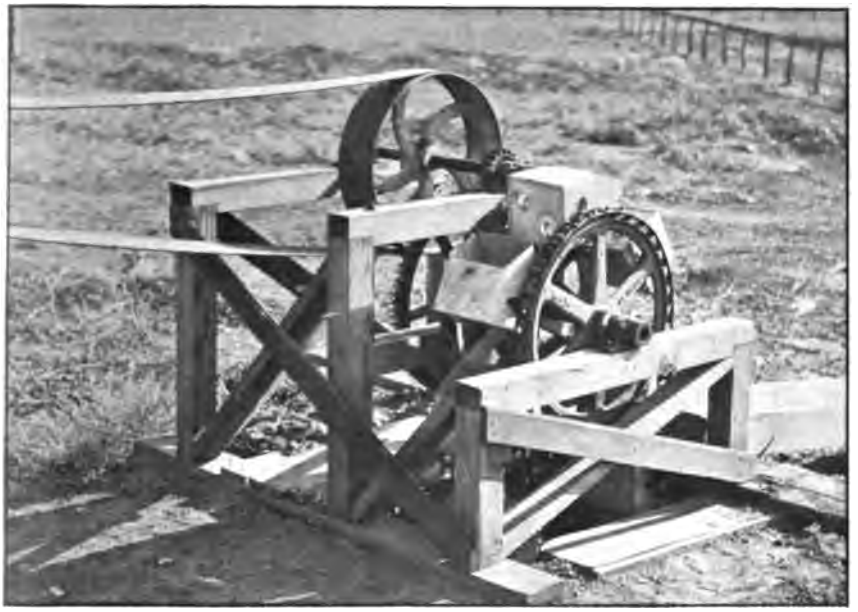


FIG. 49.—Vertical section of bucket of water elevator.

into renewed use. A modern form is shown in Pl. I, *A*. (See also fig. 49.) Its great advantages are uniformity of resistance and steady delivery. Its disadvantages are: large size for a given capacity, necessity imposed for using a large well, and difficulty in securing a perfect delivery. The buckets must be so made that in dipping into the water air will not be entrapped, and so that when delivering air may again readily enter. It has so far not been found practicable entirely to prevent loss from spilling of a portion of the water lifted. Furthermore, for emptying, the lift has to exceed somewhat the height of the discharge point. From these two inherent defects results a noticeable failure in efficiency.

SEAMAN BUCKET LIFT.

A lift designed for irrigation work, and made by Seaman & Schuske, of St. Joseph, Missouri, was tested, and the result appears



A—VIEW OF LINK-BELT WATER ELEVATOR.

B.—VIEW OF BOYCE WATER LIFT.

in fig. 50. This device consists of a series of galvanized-iron buckets, riveted to lugs carried on a common link belt. The sprocket chains, at each side of the bucket, are carried on two sprocket wheels. Each bucket is provided with a clay-ball valve, carried in a wire cage at the bottom of the bucket. The leather clack valve is a very old form for this use. With the rise of the bucket the valve—of whatever design—covers a circular aperture in the bucket bottom, and

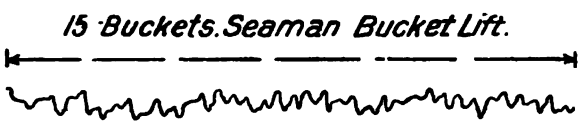


FIG. 50.—Dynamometer diagram showing uniformity of resistance afforded by Seaman bucket lift.

opens in turn with the descent into water, thus obviating the possibility of entrapping air. In the pendent loop of the chain two sprocket wheels on a shaft run without bearings. A gear on the main sprocket shaft is driven by a pinion, the power for which may be derived from any source.

The uniformity of the resistance offered by this lift is shown in fig. 50, taken from a recording dynamometer when the device was delivering about 300 pounds of water per minute, from a depth of 18.8 feet.

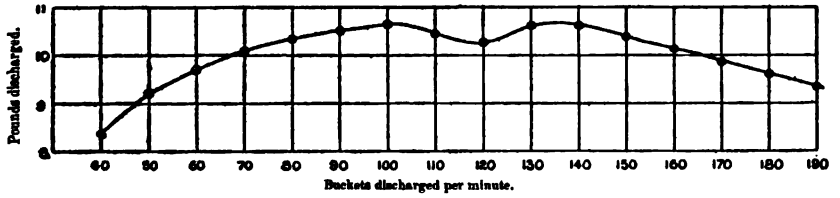


FIG. 51.—Discharge per bucket of Seaman bucket lift at various speeds.

Fig. 51 gives the discharge per bucket at various speeds, and fig. 52 the total discharge. The efficiency, as shown in fig. 53, is about 60 per cent at the favorable speed of 100 buckets per minute. A peculiar drop appears in the discharge record at speeds ranging from 100 to 130 buckets per minute. At very slow speed the discharge is less, due to leakage around the valve, and due, further, to failure of the buckets to empty into the discharge chute. At higher speed the valve loss becomes small, but the buckets soon pass the discharge

chute before fully emptying. At still higher speed centrifugal force aids greatly in discharging the bucket and temporarily increases the discharge. As speed still further increases, however, swaying of the chain causes loss, by slopping, from the rising buckets.

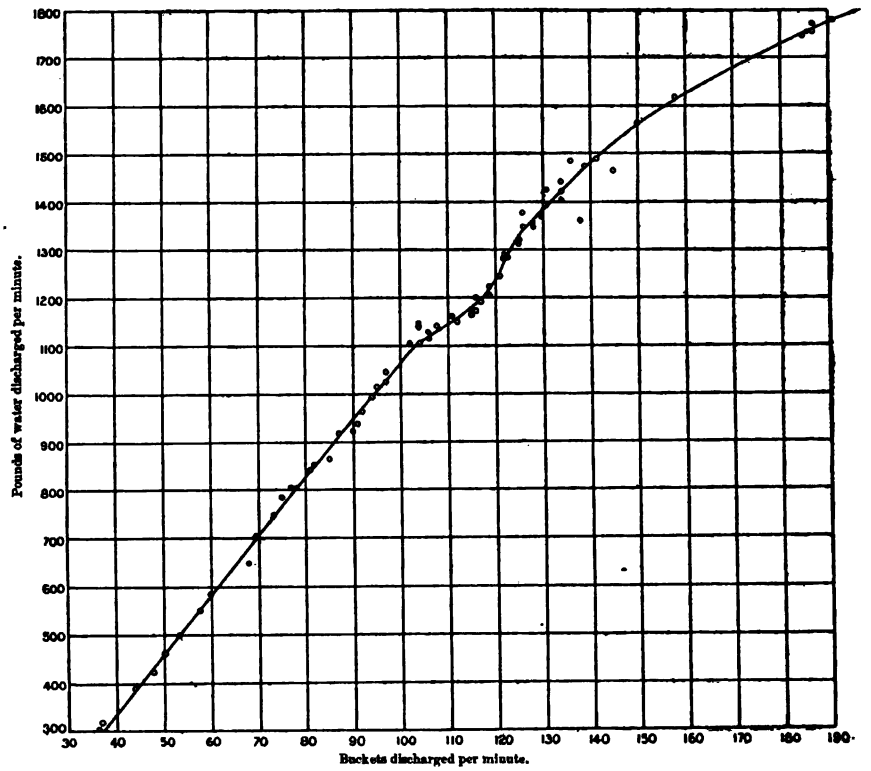


FIG. 52.—Total discharge of Seaman bucket lift at various speeds.

This pump has been successfully used in connection with a windmill. It can be recommended wherever a large open well is available, and where the depth to water is moderate, say from 20 to 35 feet. It

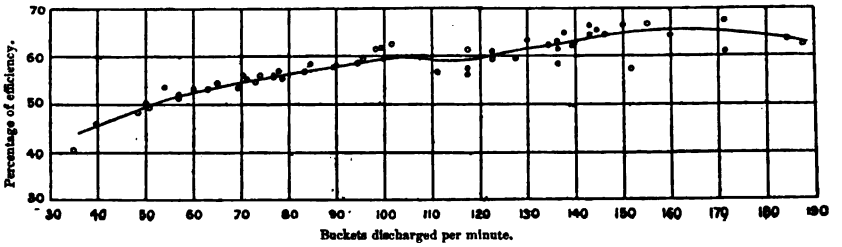


FIG. 53.—Efficiency curve of Seaman bucket at lift of 18.8 feet.

is best adapted to small powers of from 1 to 5 horsepower. The power necessary to operate such a pump is about double that represented by the useful work done, in water raised and discharged.

Discharges of Seaman bucket lift at various speeds.

Speed, in buckets per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per bucket.	Speed, in buckets per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per bucket.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
38	315	310	8.158	117	1,191	1,193	10.19
44	389	385	8.75	118	1,205	1,205	10.21
48	423	433	9.02	119	1,223	1,218	10.23
58	555	558	9.62	121	1,247	1,254	10.31
68	651	682	10.03	122	1,286	1,273	10.43
73	750	743	10.17	122	1,290	1,273	10.43
75	768	770	10.26	123	1,295	1,290	10.48
77	805	798	10.3	124	1,281	1,307	10.54
78	803	804	10.31	125	1,317	1,321	10.57
81	841	841	10.38	126	1,348	1,335	10.59
85	866	889	10.45	126	1,379	1,335	10.59
87	918	912	10.48	128	1,358	1,360	10.62
90	923	948	10.53	128	1,351	1,360	10.62
91	937	960	10.55	130	1,380	1,382	10.63
92	963	972	10.56	130	1,367	1,382	10.63
94	974	996	10.59	131	1,427	1,395	10.64
94	993	996	10.59	133	1,412	1,415	10.64
95	1,114	1,008	10.61	134	1,404	1,426	10.64
97	1,025	1,032	10.63	134	1,420	1,426	10.64
97	1,044	1,032	10.63	134	1,442	1,426	10.64
98	1,014	1,044	10.65	136	1,437	1,447	10.64
99	1,094	1,056	10.66	138	1,362	1,465	10.61
99	1,024	1,056	10.66	139	1,477	1,475	10.61
102	1,108	1,092	10.70	141	1,490	1,492	10.58
104	1,107	1,114	10.71	144	1,534	1,513	10.5
104	1,146	1,114	10.71	145	1,461	1,520	10.48
106	1,123	1,127	10.63	149	1,559	1,548	10.4
106	1,127	1,127	10.63	150	1,561	1,556	10.37
106	1,114	1,127	10.63	158	1,618	1,610	10.12
108	1,140	1,138	10.53	178	1,685	1,718	9.65
111	1,149	1,151	10.37	185	1,745	1,750	9.46
111	1,161	1,151	10.37	186	1,752	1,755	9.42
112	1,151	1,155	10.31	186	1,697	1,755	9.42
115	1,170	1,175	10.22	186	1,720	1,755	9.42
115	1,175	1,175	10.22	187	1,757	1,758	9.4
116	1,200	1,185	10.21	187	1,752	1,758	9.4
116	1,175	1,185	10.21	191	1,779	1,779	9.31

Figures from efficiency tests of Seaman bucket lift.

USEFUL LIFT, 18.8 FEET.

Speed, in buckets per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to machine per minute.	Mechanical efficiency.	Lift.
	Pounds.			*Per cent.*	*Feet.*
35.3	275	5,170	12,675	40.8	18.8
39.7	330	6,270	13,564	46.2	19
48.4	440	8,272	17,008	48.6	18.8
50	460	8,648	17,245	50.1	18.8
50.4	465	8,835	17,883	49.4	19
54	508	9,652	17,931	53.8	19
57.1	547	10,393	20,257	51.3	19
57.1	547	10,393	20,025	51.9	19
60	584	11,116	20,921	53.1	19
63.1	621	11,799	22,132	53.3	19
65.2	648	12,312	22,488	54.7	19
69.7	705	13,395	25,218	53.1	19
70.6	713	13,547	24,143	56.1	19
71.4	724	13,756	24,859	55.3	19
73	743	14,117	25,825	54.6	19
74	757	14,393	25,644	56	19
77	794	15,086	27,388	55	19
77.9	804	15,115	26,422	57.2	18.8
78.9	815	15,322	27,563	55.6	18.8
83.3	870	16,356	28,740	56.9	18.8
84.5	884	16,619	28,319	58.6	18.8

Figures from efficiency tests of Seaman bucket lift—Continued.

USEFUL LIFT, 18.8 FEET—Continued.

Speed, in buckets per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to machine per minute.	Mechanical efficiency.	Lift.
	Pounds.			*Per cent.*	*Feet.*
89.5	942	17,898	30,937	57.8	19
90	948	17,822	30,721	58	18.8
94.4	1,000	18,800	32,235	58.3	18.8
95.9	1,020	19,176	32,415	59.1	18.8
96.3	1,048	19,912	32,124	61.9	19
96.3	1,048	19,702	32,014	61.5	18.8
100	1,068	20,078	33,674	59.6	18.8
101.7	1,090	20,492	32,620	62.8	18.8
107.1	1,133	21,300	35,529	59.9	18.8
111.1	1,152	21,657	36,076	56.8	18.8
117.6	1,200	22,800	37,226	61.2	19
117.6	1,200	22,560	40,160	56.1	18.8
117.6	1,200	22,560	39,211	57.5	18.8
122.5	1,284	24,139	40,628	59.4	18.8
122.5	1,284	24,139	39,453	61.1	18.8
127.6	1,355	25,474	42,633	59.7	18.8
130	1,382	26,258	41,502	63.2	19
134.8	1,435	26,978	43,386	62.1	18.8
136	1,448	27,512	43,607	63	19
136.4	1,450	27,260	46,760	58.3	18.8
136.4	1,450	27,260	44,405	61.3	18.8
137.9	1,463	27,797	42,816	64.9	19
139.5	1,480	27,824	44,809	62.1	18.8
143	1,505	28,595	43,584	65.6	19
143	1,505	28,595	44,442	64.3	19
144.6	1,516	28,804	44,198	65.1	19
146.3	1,530	29,070	45,068	64.5	19
150	1,556	29,564	44,541	66.3	19
151.9	1,570	29,830	52,101	57.2	19
154	1,584	30,096	45,002	66.8	19
160	1,622	30,818	48,075	64.1	19
171.4	1,685	32,015	47,028	67.2	19
171.4	1,685	32,015	47,436	67.5	19
171.5	1,687	31,715	52,199	60.7	18.8
184.6	1,748	33,212	51,996	63.8	19
187.5	1,760	33,440	53,337	62.7	19

SAME USING TWO VALVES IN EACH BUCKET.

96	1,022	19,401	35,447	54.7	18.8
100	1,069	20,204	36,738	55	18.9
100	1,069	20,078	36,604	54.8	18.8
102.5	1,098	20,642	37,205	55.4	18.8
103.4	1,108	20,941	37,109	56.4	18.9
111.1	1,152	21,657	39,361	55	18.8
115.4	1,178	22,190	40,960	54.1	18.8
122.5	1,288	24,120	42,151	57.2	18.8
125	1,323	24,872	42,830	58	18.8
130.4	1,383	26,138	44,058	59.3	18.9
133.3	1,420	26,838	45,895	58.4	18.9
142.8	1,505	28,294	50,222	56.3	18.8
142.8	1,505	28,294	50,770	55.7	18.8
142.8	1,505	28,444	48,856	58.1	18.9
151.9	1,570	29,516	50,724	58.2	18.8
162.1	1,684	30,719	54,718	56.1	18.8
169	1,673	31,452	54,830	57.2	18.8
184.6	1,749	32,881	62,924	52.2	18.8
187.5	1,760	33,088	63,337	52.2	18.8

LIFTING BY ANIMAL POWER.

It is somewhat surprising that horses are not more used for lifting water. In small operations, or where a farmer is experimenting with a view to irrigation, horse power would seem to be the resource readiest to hand. It is but little recognized how much work may be got

from a horse if a suitable device be provided. Farm horses, like their masters, work especially hard during special seasons. Their rate is higher then than it could be if they were worked continuously. If the following estimates at first sight appear low, it should be understood that they are made on the assumption of a uniform daily rate. It is assumed that a good work team of two horses will pull 300 pounds steadily during a day of eight hours. In plowing, this effort is frequently doubled. For horses worked continuously at a straight-away pull, 125 pounds each for medium-weight horses is good average work. For occasional short periods a horse can throw one-third of his weight into his effort, but he can not do so at frequently recurring intervals. The maximum load for a horse, if recurring at short intervals, should not exceed double the average fair load, and the more frequently it recurs the less it should be. The natural gait of a work horse is about 3 feet per second. If loaded to pull 125 pounds at this gait, his work would be equivalent to 22,500 foot-pounds per minute, or about two-thirds of a horsepower.

If a horse could be worked steadily at some device the efficiency of which would be 66 per cent, he could lift, in a ten-hour day, $\frac{3.3}{L}$ acre-feet of water, L being the height of lift in feet. In many cases the lift will be about 15 feet, giving an output per horse of 0.22 acre-foot, and if the depth of irrigation be 3 inches, accompanied with the usual waste, the water for about three-fourths of an acre per day could easily be supplied by two horses. With storage and with intervals of ten days between irrigations a team of two horses could care for from 5 to 7 acres. While to the enthusiast these figures will not appear large, they are large enough to justify the use of horses in small undertakings. The assumed efficiency of 66 per cent is, in fact, low rather than high, and a device for the utilization of horsepower that shall attain to this percentage ought to be possible of achievement by mechanical skill.

The foregoing is a statement of what it is possible to do with horses if suitable machinery be provided; but the majority of existing devices will not do so well as this. As shown by the stress diagram for a single-cylinder pump (fig. 39, p. 66), the maximum stress is more than three and one-half times what would be the average stress. As the maximum effort of a horse should not rise to more than double his average effort, and as the average resistance in the single-cylinder pump is 28 per cent of the maximum resistance, the actual average load put on the horse can equal only 28 per cent of twice his average effort, or 56 per cent of his possible average effort. In order to get full work out of a horse, therefore, it would be necessary, at some period of each pump stroke, for him to make an effort more than three and one-half times his most efficient average effort. This would be too great irregularity of exertion.

A horse can not do full work on an unbalanced single-cylinder pump. It is imperative that recourse be had to some device which will more nearly equalize his efforts. The use of a sweep, by reason of the circular course a horse has to follow, involves a loss of 20 per cent of efficiency, as compared with the possible efficiency in a straight-away pull. At each point of his actual course he will be pulling at an angle with his most effective course, which at any point will always be a tangent to the circular path. Tests of the usual sweep horse-power show an efficiency of about 80 per cent.

A horse can deliver to a pumping device, through the medium of a sweep, 80 per cent of 80 per cent, or 64 per cent of his best effort. If the pumping device have an efficiency of 60 per cent, such as shown by the bucket lift, the water actually lifted will represent 80 × 80 × 60 per cent, or 38.4 per cent straight-away average effort of the horse. In the operation of a bucket lift of this kind,

$$\frac{8640}{\mathrm{L}} = p,$$

in which L is the total lift of water in feet, and p the number of pounds discharged per minute for each horse employed.

To determine the proper speed for the bucket lift, let S be the length of sweep in feet, L the lift of water in feet, l b d the dimensions, respectively, of the buckets used in inches, and n the number of buckets emptied during one revolution of the sweep; then, for each horse

$$\frac{10{,}400\,\mathrm{S}}{\mathrm{L}\,l\,b\,d} = n.$$

Omitting from consideration what might be done by overtaxing the horse, a larger output than this is to be looked for only through increase of efficiency in the mechanism of either the sweep or the pump. This low efficiency, in which but 38 per cent of the power expended by the horse appears as returned in useful work, lies at the root of the nonuse of horsepower for these light water-lifting operations. As already stated, the difficulty does not to the writer appear insuperable.

SOME INDIAN DEVICES.

Among devices employed in India for raising water from wells by animal power a number have been tested as to their mechanical efficiencies, and have been reported upon to the Madras government in Bulletin No. 32 of the department of land records and agriculture, under the title, Experiments with Water Lifts. The following copious extracts from this interesting report, together with figs. 54, 55, and 56, which are selected reproductions from its plates, show what may be accomplished with these rude devices of the Indian farmer, to whom the cost of modern machinery is, as a rule, prohibitive.

The experiments conducted by the committee had the following objects in view: The determination of—

(1) The quantity of water and the effective height it was lifted in a given time by bullocks of known weight, and working in a way that did not unduly fatigue them.

(2) The quantity of work actually obtained from the animals in the same time.

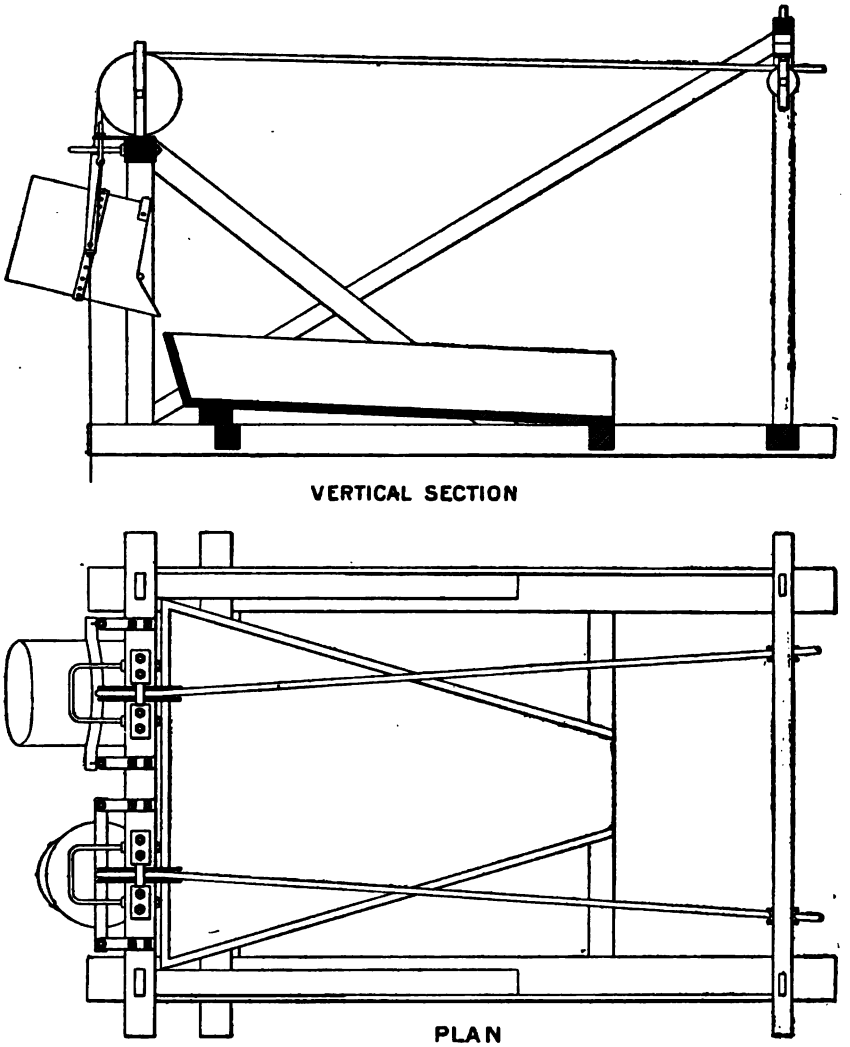


FIG. 54.—Plan and vertical section of Stoney water lift.

(3) The quantity of work which might have been obtained from the animals in the same time had the working of the lifts been continuous.

The first quantity divided by the second gives the mechanical efficiency of the water lift, and the first quantity divided by the third gives its absolute efficiency as a machine for utilizing animal power in a given way.

(4) The quantity of work represented in water lifted per hour divided by the weight of the bullocks in pounds.

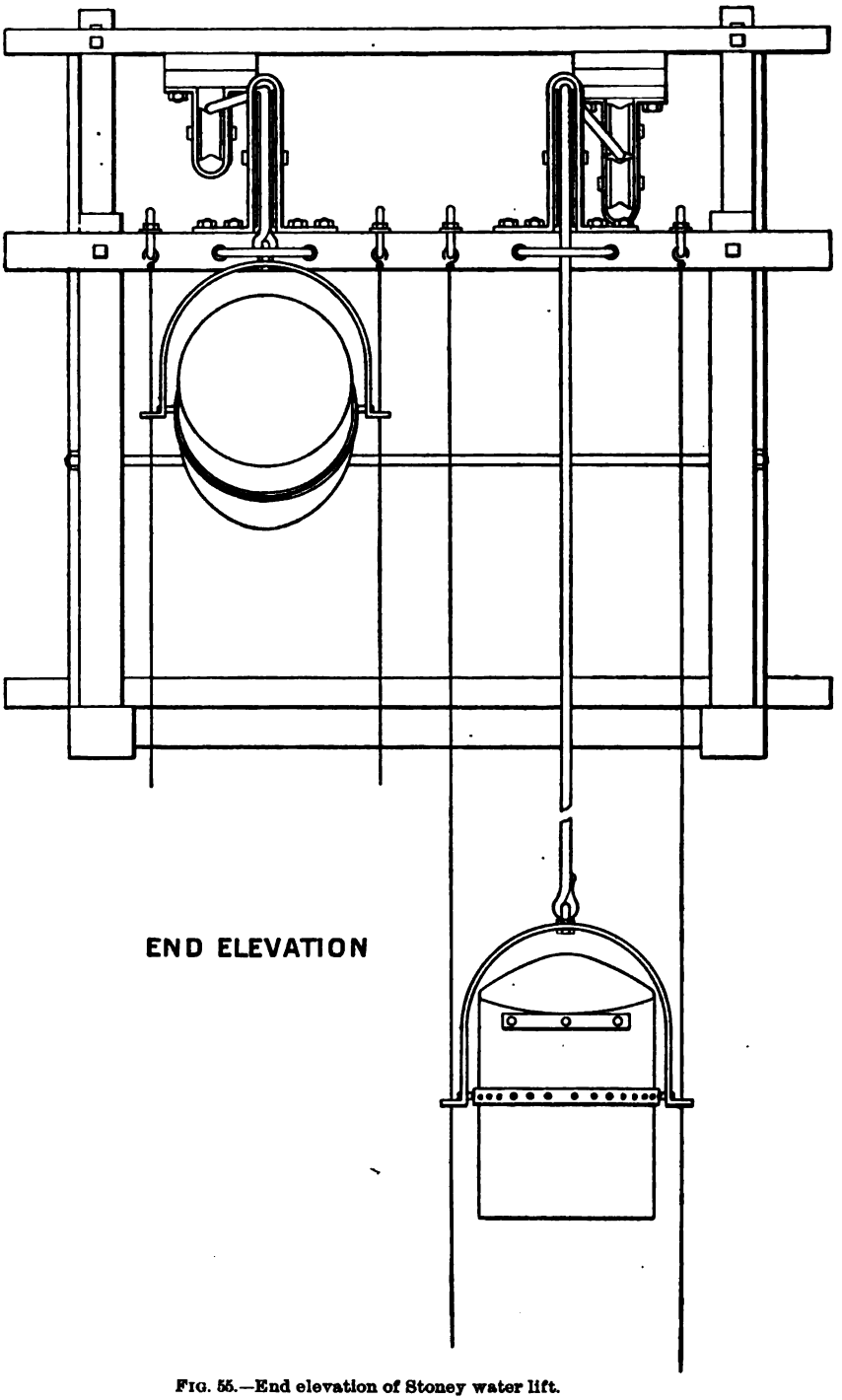


FIG. 55.—End elevation of Stoney water lift.

This yields a constant which, on the assumption that the animals employed in working the various lifts are all equally strained, enables a comparison to be made between very different types of water lift and very different methods of applying animal power. In some lifts only the draft of the animals is utilized. In others, as for instance the ordinary single mhote, both draft and weight are utilized, whilst in a third class only the animals' weight is made use of, as in Mr. Subba Rao's oscillating platform; and between such very different methods the constants yielded by (4) seems to be the best method of making comparisons of the actual value of different machines for lifting water. It must be remembered

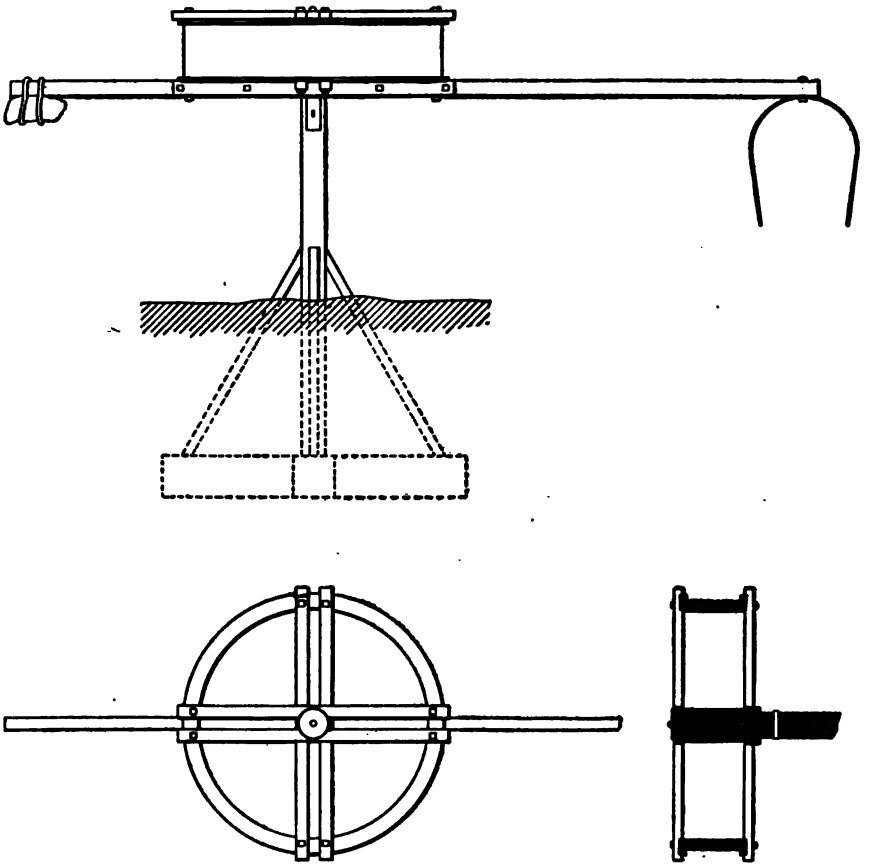


FIG. 56.—Whim used with Stoney water lift.

that though the mechanical efficiency of a water lift may be high, yet the mode of getting the work out of the animals employed may be bad, and the actual value of the constants yielded by (4) depends on the assumption that the strength of animals is proportional to their weight, which is probably roughly true for animals in good working condition and in the prime of life, and on the accuracy with which it is possible to estimate whether two animals working in different ways are exerting themselves to their full working capacity. The figures therefore obtained are only to be taken as offering a rough method of comparing the different lifts, and as a guide in estimating their probable value as machines for lifting water.

Stoney's water lift.—The principal feature in this lift is the employment of buckets of wrought iron, suspended in a stirrup by two adjustable pivots attached to the bucket very slightly above the center of gravity of the bucket when full of water. The mouth of the bucket is inclined as shown in the drawing, and the lower ends of the stirrup are turned outward and encircle steel wires which are suspended in the well from screw eyebolts attached to the framing above. The wires are fastened by some convenient means to the bottom of the well and act as guides to the bucket, ascending and descending, and prevent it from either turning round or swaying to and fro, and thus striking either the sides of the well or the second bucket. On the bucket being lowered into the water it turns horizontally and rapidly fills with water, and on being drawn up assumes a vertical position and rises steadily out of the water, till the discharging level is reached, when the upper side of the inclined mouth comes into contact with an iron bar fixed across the framing of the lift, and the stirrup, continuing its upward motion, causes the bucket to revolve about the point of contact of the bucket with the iron rod, and thus discharge its contents into the delivery trough. The lift was worked by carrying the ropes which hold the buckets over guide pulleys to a whim turned by either a pair of bullocks or a single bullock. Two buckets were attached and the ropes arranged so that as one bucket ascended the other descended, and the dead weight of the buckets was balanced. The whim consisted of a drum built of wood and carried by an iron spindle on the top of a post firmly built into the ground. The bullocks worked at the end of a long arm, the circumference swept out by which was 3.85 times the circumference of the drum. The whim is worked alternately in one direction and the other, the cattle being made to turn round while the bucket is discharging its contents. The lift was provided with two sets of buckets of a nominal capacity of 30 and 25 gallons (English), respectively. In the following table is exhibited the data regarding their capacity:

TABLE I.

		Weight, empty.	Weight of water when full.	Weight of water delivered by buckets.
		Pounds.	*Pounds.*	*Pounds.*
30-gallon buckets	No. 1	101	296	280
	No. 2	98	295	280
25-gallon buckets	No. 1	68	245	230
	No. 2	67	237	230

The capacity of the lift was tested by working it with a single Nellore bullock weighing 1,146 pounds on three different days, but owing to insufficiency of water in the well no test could be continued for more than two hours forty-two minutes. In Table II the results obtained are shown:

TABLE II.

Date.	Time started.	Time stopped.	Number of buckets raised.	Lift at beginning.	Lift at end.	Mean lift.	Gallons raised per hour.	Foot-pounds of useful work done.
				Ft. in.	*Ft. in.*			
July 16, 1895	8-37	9-37	*a* 88	22 0		22.625	2,594	586,900
	9-37	10-07	*a* 51		23 3			
	2-04	3-04	*a* 91	21 10½				
	3-04	4-04	*a* 86			23.24	2,489	575,500
	4-04	4-46	*a* 63					
July 17, 1895	2-00	3-00	*a* 85	22 2		22.87	2,391	546,900
	3-00	3-51	*a* 73		23 6½			
July 18, 1895	2-29	4-29	*b* 167	22 2		22.75	1,886	429,069
	4-29	5-29	*b* 79		23 4			

a 30-gallon buckets. *b* 25-gallon buckets.

The mechanical efficiency of the lift when just moving is 83.6 per cent, and at the ordinary working speed, 79 per cent. It was found that the speed at which the bullock walked when exerting a draft of 92 pounds was, as the mean of a number of observations, 3.64 feet per second, and that in 162 minutes he raised 240 buckets of water, lifting each bucket 23 feet. Walking at this speed without stopping, which without doubt the animal could have easily done, he could have lifted 401 buckets, so that he was only usefully employed for 59.7 per cent of the time. The absolute efficiency of the lift was therefore 79 by 59.7 per cent or 47.2 per cent. This calculation neglects to take into account the extra pull which is necessary to tilt the bucket to make it discharge, which was found to amount to 122 pounds and which was exerted through about 3 feet. This quantity would only affect the result very slightly and the decrease in efficiency would diminish as the height to which the water has to be raised increases.

A device of this kind is among the possibilities of home manufacture in any American community. The results given were obtained from actual trial and could be duplicated here by the use of horses.

A device called an improved single mhote was also tested and described. A water carrier holding 31 gallons was provided, at its bottom opening, with a large leather pipe. This carrier or bucket was suspended by a rope from a pulley, and the free end of the leather discharge pipe was separately suspended and held up by a second rope passing over a pulley below the bucket pulley at the ground surface. The discharge end of the leather pipe was ordinarily held above the bucket, and in this position permitted no discharge. Upon the ascent of the bucket and its upturned discharge pipe or leather tube the tube would be drawn out along the ground by its controlling rope and discharge effected as soon as the bucket passed above the ground surface. The two ropes were connected in such manner that they were operated together, the pull being exerted by bullocks descending an inclined plane which had been excavated below the ground level.

The improvement on the ordinary single mhote is effected by attaching a rope to the draft rope and carrying it on to the large drum of a kind of windlass erected at the end of the inclined plane and at a considerable height above the level of the end of the run. Cords wound round two smaller drums, one on each side of the large drum, carry weights, which it was found almost balanced the weight of the empty bucket, so that at the end of a lift, as soon as the bucket was empty, the draft rope automatically rose in the air and the bullocks were able to turn round and walk up the inclined plane in a natural, easy manner instead of being forced backward, as is the common plan. The improvement effected is undoubtedly a very great one, as not only is the weight of the empty bucket practically balanced, but the animals are also spared the cramped and unnatural backward walk up a steep incline, which probably tires them more than their exertions in drawing the bucket out of the well. The experiments made on this lift were not very extensive, but the following results were obtained and are worthy of record. The mhote was worked by two bullocks weighing 732 pounds and 616 pounds, respectively, or in the aggregate 1,348 pounds. The bucket, which was of iron and fitted with a leathern discharge trunk, weighed 43 pounds and when full held 31 gallons of water, but the mean quantity lifted, as measured into a tank, was 24.2 gallons per lift, the rest being spilt or lost by leakage. With the bullocks employed the rate of working was 90 lifts per hour, and the height of the lift being 23 feet, the total quantity of work usefully done amounted to 500,940

foot-pounds per hour. The draft exerted by the bullocks down the inclined plane was found to be 383 pounds. The useful work done in a single lift was 24 × 10 × 23 or 5,570 foot-pounds, whilst the bullocks exerted a pull of 383 pounds through 25¼ feet, the bucket having to be raised an extra 2¼ feet to enable it to discharge its contents, and the work done is equal to 9,760 foot-pounds. The bullocks then had to return up a gradient of 1 in 5.28 feet, in doing which they expended 6,510 foot-pounds of energy in lifting their own weight against the action of gravity. The total amount of work done by them in a single lift was, therefore, 16,570 foot-pounds and the useful outturn 5,570 foot-pounds, so that the efficiency of this method of lifting water is not greater than 34.3 per cent. As compared with the ordinary single mhote, the great advantage which this lift possesses is that it allows the bullocks to turn round at the bottom of the inclined plane and ascend walking forward instead of backward, an advantage which it would be difficult to express numerically, but the balancing of the bucket diminishes the draft by about 40 pounds and increases the efficiency of the lift by about 6.3 per cent, not, perhaps, a very large amount, but still by no means a negligible quantity.

A see-saw lift described is unique, and might be developed into a practical device:

In this form of water lift the bullock is made to walk along a platform supported on a roller, and by his weight it is caused to oscillate up and down. Two ropes are attached to one end of the platform and wound round two small drums forming part of a windlass, round the large drum of which a rope working an ordinary single mhote is passed. The platform is not supported in the middle, but at some distance therefrom, so that the working end of the platform greatly preponderates and the bullock has to walk to the free end of the platform to tilt the longer segment up and lower the bucket into the well. The platform is 24 feet long and the supporting roller is fixed 15 feet 3¼ inches from the working end. It was not possible to weigh the platform, and calculations of its weight, based upon the quantity of timber used in it, can only be approximate. It was, however, carefully measured up, and assuming that the teak wood, of which it was constructed, weighed 45 pounds per cubic foot, the weights of the two sections are 1,450 pounds and 850 pounds. To diminish the shock when the free end falls and the bucket is lowered into the water, 230 pounds of iron rails are fastened underneath the platform by a short chain, so that just before this end of the platform reaches its lowest position the rails rest on the ground and their weight ceases to act, and the platform comes to rest more gently than would be the case if the velocity of descent continued to accelerate to the very end. The ropes from the platform were wound round drums, the circumference of which was 3 feet 2¼ inches as measured by unwinding one coil of the rope, and the mhote rope was worked from a drum 7 feet 10 inches in circumference so that the motion of the working end of the platform was multiplied 2.44 times. With the bucket empty and the platform horizontal the load at the free end could be varied from 160 pounds to 362 pounds without disturbing the equilibrium, whilst with a load of 247 pounds in the bucket, equal to 24.7 gallons of water, the platform remained horizontal, though the load at the working end varied between 584 pounds and 275 pounds. Taking the mean between the two extreme values to be the actual weight required to balance the platform, it is possible by taking moments about the center to determine the only force acting on the platform which was not measured, viz, the weight of the empty bucket and ropes acting with a lineage of 2.44 to 1. With the bucket unloaded, the weight works out as 65.4 pounds and when loaded 62 pounds, a remarkably close agreement.

The lift was worked during the trial by a bullock weighing 700 pounds and a man weighing 117 pounds. The rate of working was 81 lifts per hour from a well 18 feet 1 inch deep. The average quantity of water brought up by the bucket, as measured into a tank, was 23.5 gallons, and the useful work done per hour

amounted to 344,210 foot-pounds. The bullock and the man together were much heavier than was really necessary, and they did not use the full length of the platform, so that it is difficult to estimate the work done by them in working the lift, but the mechanical efficiency of the lift on the day of trial can be ascertained by multiplying the fall of the front end of the platform by the force required to set it in steady motion when lifting a bucket full of water. The total height the bucket had to rise to discharge its contents was 22 feet, and the end of the platform therefore fell 9 feet and the work done was $584 \times 9 = 5{,}256$ foot-pounds. To raise the platform back to its initial position the free end then falls 5.18 feet and the load on it is 362 pounds, and the work done is equal to 1,875 foot-pounds. The total work, therefore, done in a single lift is 7,131 foot-pounds, and the useful work given to the water is 4,245 foot-pounds, so that the mechanical efficiency, when just working, is 59.6 per cent; at the normal rate of working it is much lower, probably not more than 50 per cent.

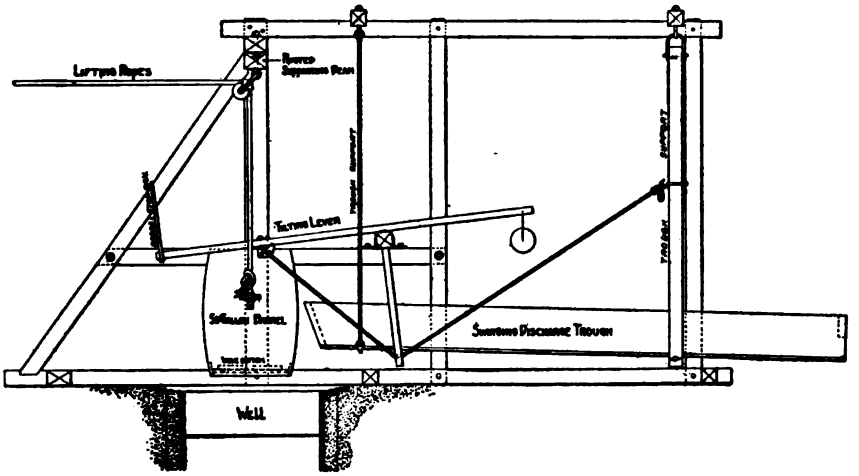


FIG. 57.—Construction of Boyce water lift.

The conclusion reached by the engineer, Mr. A. Chatterton, who made the tests, was that "the most efficient way of utilizing animal power is to make the animal raise himself against the action of gravity, and then, in some way, convert the potential energy stored in the animal's body into work."

AN AMERICAN DEVICE.

An American water lift, devised by Mr. A. Boyce, of Augusta, Oklahoma, was exhibited at Garden, Kansas, in 1896. Figs. 57, 58, and Pl. I, *B* (p. 74), show its construction and general mode of operation. Its very considerable merit lies in the readiness with which it may be constructed on the farm, and in its cheapness. The general plan of the device may be described as follows:

The running gear of an ordinary farm wagon, with the two wheels of one side removed, has its axles fixed radially to a circular track, the diameter of which is made to exceed slightly the total height of the water lift. The axles are bolted to beams which extend to the center of the circular track, where they are pivoted to a low post.

Horses hitched in the usual manner draw this two-wheeled device around the circle. A vertical post, rigidly braced on the wagon frame and extending to a height somewhat above the backs of the horses, carries at its upper end a vertical pin, to which ropes are attached by means of a loose link and extended to a lifting device at the well. As the wagon travels around the track, the framework, as a whole, acts as a crank, the throw of which is equal to the height of lift of the water. The ropes extend horizontally from the top of the traveling post to the well framework, so that the horses pass beneath them. By simple multiplication of ropes more than one well may be drawn upon. Where, however, there is but a single well, a counterbalance upon the wagon must be used to prevent overturning. In the well is a bucket, hung at either side on gimbals, attached a little above its center of gravity when full, so as barely to insure stability. In the bottom of the bucket two large clack valves admit of the ingress of water. The supporting ropes, one on each side, pass through pulley blocks over head and thence horizontally to the crank link on the wagon post. These pulley blocks hang from the ends of a short beam, pivoted at its center so that it may always maintain a position normal to the continually changing direction of the ropes.

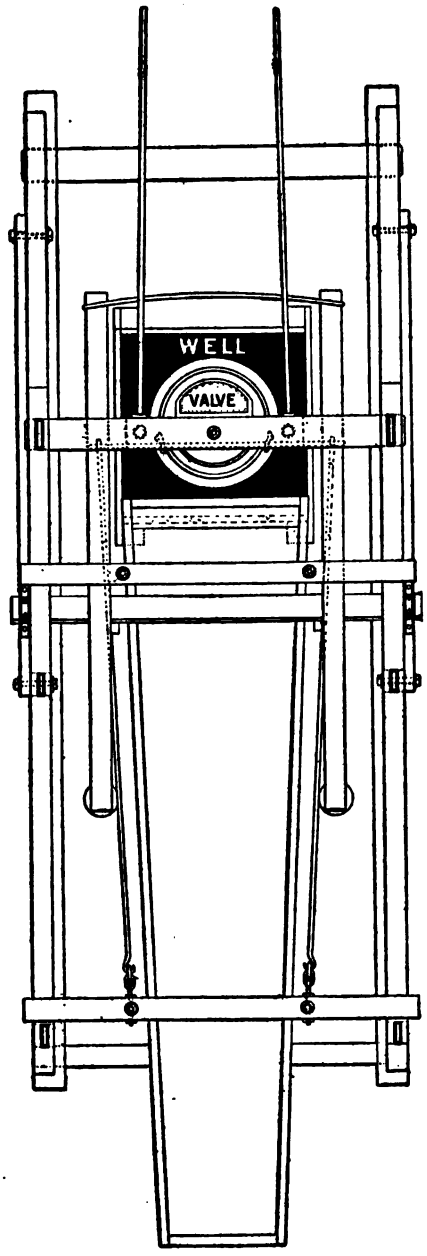


FIG. 58.—Construction of Boyce water lift.

The mechanism for emptying the bucket is designed to receive its full discharge and at the same time to avoid shock. A swinging trough is suspended at four points, by rods, from the framework overhead. As the bucket reaches the summit of its rise it encounters a cross rod, on a tilting lever, as shown

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 15

OPERATIONS AT RIVER STATIONS, 1897.—PART I

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888–89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and a report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889–90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890–91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering," and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 15

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

OPERATIONS AT RIVER STATIONS, 1897

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART I

WASHINGTON

GOVERNMENT PRINTING OFFICE

1898

CONTENTS.

	Page.
Lambertville station on Delaware River	7
Harrisburg station on Susquehanna River	8
Rowlandsville station on Octoraro Creek	12
Woodstock station on Patapsco River	13
Laurel station on Patuxent River	14
Cumberland station on Potomac River	15
Sharpsburg station on Antietam Creek	16
Port Republic station on North and South rivers	17
Millville station on Shenandoah River	19
Frederick station on Monocacy River	20
Point of Rocks station on Potomac River	21
Park station on Rock Creek	22
Glasgow station on North River	23
Buchanan station on James River	24
Roanoke station on Roanoke River	25
Clarksville station on Dan and Staunton rivers	26
Neal station on Roanoke River	28
Tarboro station on Tar River	29
Selma station on Neuse River	30
Fayetteville station on Cape Fear River	31
Salisbury station on Yadkin River	32
Norwood station on Yadkin River	33
Catawba station on Catawba River	34
Rockhill station on Catawba River	35
Gaffney station on Broad River	36
Alston station on Broad River	37
Waterloo station on Saluda River	38
Calhoun Falls station on Savannah River	39
Carlton station on Broad River	40
Carey station on Oconee River	41
Dublin station on Oconee River	42
Almon station on Yellow River	43
Macon station on Ocmulgee River	44
Molena station on Flint River	45
Oakdale station on Chattahoochee River	46
West Point station on Chattahoochee River	47
Canton station on Etowah River	48
Carters station on Coosawattee River	49
Resaca station on Oostanaula River	50
Riverside station on Coosa River	51
Wetumpka station on Coosa River	54
Milstead station on Tallapoosa River	56
Tuscaloosa station on Black Warrior River	57
Alderson station on Greenbrier River	58
Fayette station on New River	59
Asheville station on French Broad River	60
Bryson station on Tuckaseegee River	61
Judson station on Little Tennessee River	62
Murphy station on Hiwassee River	63
Chattanooga station on Tennessee River	64

Page.
Townsend station on Missouri River 65
Salesville station on West Gallatin River 66
Bozeman station on Middle Creek 67
Logan station on Gallatin River 68
Redbluff station on Madison River 69
Threeforks station on Madison River 70
Sappington station on Jefferson River 70
Great Falls station on Sun River 72
Chinook station on Milk River 73
Livingston station on Yellowstone River 74
Miscellaneous discharge measurements in Montana 75
Meeteetse station on Grey Bull River 75
Lovell station on Shoshone River 76
Sheridan stations on Big and Little Goose creeks 77
Buffalo station on Clear Creek 78
Crawford station on White River 79
Fort Niobrara station on Niobrara River 80
Woods Landing station on Laramie River 81
Uva station on Laramie River 82
Orin Junction station on North Platte River 83
Gering station on North Platte River 84
Camp Clarke station on North Platte River 85
North Platte station on North Platte River 86
Deansbury station on South Platte River 87
Denver station on South Platte River 88
Orchard station on South Platte River 89
Morrison station on Bear Creek 90
Marshall station on South Boulder Creek 91
Boulder station on Boulder Creek 92
Lyons station on St. Vrain Creek 93
Arkins station on Big Thompson River 94
St. Paul station on North Loup River 95
St. Paul station on Middle Loup River 96
Columbus station on Loup River 97
Columbus station on Platte River 98
Norfolk station on Elkhorn River 99
Western river stations 100

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, February 10, 1898.

SIR: I have the honor to transmit herewith brief descriptions of the river stations at which work was carried on by the Division of Hydrography of this Survey during 1897, together with tables of daily height.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

OPERATIONS AT RIVER STATIONS, 1897.

LAMBERTVILLE STATION ON DELAWARE RIVER.

Observations of height of Delaware River were begun on July 23, 1897, at the covered toll bridge at Lambertville, New Jersey, a town on the Belvidere Division of the Pennsylvania Railroad, 16 miles above Trenton. When visited, there was found to be an old gage on the bridge pier; later in the season the water receded below the end of this scale. A new gage was therefore put in place, consisting of a stamped link brass chain 33 feet long with a 6-pound sash weight attached. The chain runs over a pulley, the scale being a horizontal board 22 feet in length, graduated to tenths of a foot, fastened to the studding of the bridge and inclosed in a wooden cover. The zero of the gage chain is marked by a copper rivet. It reads 2 feet when the water is at zero on the old gage of the bridge pier. The observer is Charles H. Naylor, collector of toll. Measurements are made from the windows of this covered bridge. The initial point for soundings is on the left bank. The channel above and below is nearly straight, the water being sluggish for a short space on the left side. The right bank is high and the bed of the stream is of gravel and sand. A measurement was made on July 22, 1897, by Arthur P. Davis, when the water stood at 5.50 feet on the new gage, the discharge being 21,831 second-feet; and another on September 14, 1897, by E. G. Paul, when the gage height was 3.42 feet and the discharge 5,308 second-feet.

Daily gage height, in feet, of Delaware River at Lambertville, New Jersey, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.70	3.74	2.75	2.35	5.35	17	.....	4.45	2.95	3.35	4.40	9.00
2	.....	6.13	3.83	2.60	3.90	5.00	18	.....	4.25	2.75	3.05	4.50	7.60
3	.....	5.58	4.00	2.65	5.40	4.75	19	.....	4.16	2.85	2.75	4.45	6.85
4	.....	5.17	3.95	2.50	5.15	4.55	20	.....	4.04	2.50	2.50	4.35	6.20
5	.....	5.74	4.08	2.40	4.90	5.35	21	.....	3.91	2.55	2.45	4.25	5.60
6	.....	5.87	3.91	2.30	4.40	6.00	22	.....	3.87	2.60	2.40	4.20	5.40
7	.....	5.37	3.87	2.20	4.15	7.00	23	5.50	4.00	2.65	2.45	4.10	5.25
8	.....	5.04	3.70	2.20	3.95	6.10	24	5.25	4.17	2.75	2.60	4.10	5.25
9	.....	4.78	3.38	2.20	3.90	5.60	25	5.00	4.33	3.05	2.60	4.05	4.90
10	.....	4.52	3.00	2.20	4.15	5.40	26	4.92	5.20	3.25	2.55	3.95	4.50
11	.....	4.70	3.00	2.20	4.45	5.20	27	4.83	5.08	3.10	2.70	4.75	4.60
12	.....	4.83	3.87	2.30	4.60	5.20	28	6.12	4.69	3.40	2.55	6.20	4.50
13	.....	4.91	3.63	2.65	4.65	5.45	29	7.46	4.25	3.10	2.35	6.35	Frozen.
14	.....	4.95	3.41	3.20	4.70	6.35	30	8.75	3.95	2.85	2.30	5.65	4.20
15	.....	4.70	a3.17	3.35	4.50	8.25	31	7.75	3.74	.....	2.25	.....	4.25
16	.....	4.81	2.90	3.45	4.35	10.15							

a New gage erected. Former reading changed to refer to new datum.

HARRISBURG STATION ON SUSQUEHANNA RIVER.

Observations of the height of water in the Susquehanna River have been made for several years at the pump house of the waterworks; located in the western part of the city of Harrisburg, Pennsylvania. This well is connected directly with the river by means of large water mains. A float in this well is attached to a cable and counterweight, the height of water being indicated upon a painted scale. The datum is the low-water mark of 1804. Observations are made by the engineer, C. M. Nagle, each morning before starting the pumps. The record since 1890 has been furnished by Mr. E. Mather, president of the Harrisburg Water Company. Measurements of the discharge are made from the open iron bridge on Second street. The initial point for sounding is the iron upright at the east end of the bridge. The channel above and below the station is straight for about 2,500 feet. The banks are high and the current has moderate velocity. The stream is divided into two channels, with a large island between. The first measurement was made on March 31, 1897, by E. G. Paul.

The results of measurements during 1897 are as follows:

March 31, gage height, 5.42 feet; discharge, 58,859 second-feet.
May 15, gage height, 7.83 feet; discharge, 105,888 second-feet.
August 31, gage height, 1.50 feet; discharge, 9,568 second-feet.
September 16, gage height, 0.58 feet; discharge, 3,962 second-feet.
November 17, gage height, 2.50 feet; discharge, 17,824 second-feet.

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1891.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.83	10.58	11.00	8.25	3.58	2.00	2.75	3.25	4.67	1.75	2.50	4.25
2	3.00	11.50	9.00	9.00	3.50	1.92	2.50	3.17	4.00	1.67	2.50	4.00
3	3.33	11.50	7.33	8.58	3.42	2.00	2.58	3.08	3.67	1.67	2.33	3.67
4	4.50	11.17	6.67	8.75	3.42	2.00	3.17	2.92	3.33	1.58	2.25	3.50
5	5.25	10.17	5.67	8.42	3.25	2.00	4.08	3.00	3.00	1.58	2.25	4.58
6	5.00	8.92	5.67	8.00	3.08	2.00	3.50	3.08	3.00	1.58	2.25	8.75
7	5.50	7.67	5.25	7.17	3.00	2.08	3.08	3.00	3.83	1.58	2.17	9.50
8	5.42	7.50	5.00	6.42	3.00	2.17	2.67	3.33	4.67	1.75	2.17	8.33
9	4.92	7.50	4.67	6.00	2.92	2.58	2.75	3.08	4.50	2.58	2.00	7.00
10	4.50	7.42	4.67	5.67	2.75	2.75	2.67	2.83	4.08	3.00	2.00	6.00
11	4.08	7.50	6.17	5.33	2.67	3.00	2.92	2.75	3.83	2.83	2.00	5.42
12	4.25	7.42	7.08	6.08	2.67	2.75	2.83	2.58	3.50	2.67	2.67	5.00
13	6.00	7.00	8.50	7.33	2.58	2.67	2.75	2.58	3.08	2.67	3.67	4.17
14	8.75	6.42	9.67	9.00	2.50	2.67	2.50	2.58	3.00	2.58	4.00	4.33
15	7.92	5.92	10.75	8.50	2.50	2.58	2.25	2.50	3.00	2.42	4.25	4.00
16	7.50	5.58	10.00	8.00	2.42	2.50	2.17	2.50	2.67	2.33	4.08	3.83
17	6.67	5.92	8.83	7.67	2.42	2.42	2.00	2.50	2.67	2.08	3.75	3.75
18	6.00	14.25	7.75	7.42	2.33	2.33	1.83	2.42	2.58	2.00	4.00	3.67
19	5.67	19.00	6.83	6.83	2.25	2.33	1.92	2.25	2.58	1.83	4.83	4.58
20	5.08	17.83	6.17	6.75	2.25	2.33	2.08	2.42	2.50	1.92	4.75	5.00
21	4.83	13.25	5.92	6.33	2.04	3.33	2.08	2.25	2.25	2.17	4.67	4.75
22	4.50	11.75	6.33	5.92	2.00	3.58	2.08	2.08	2.17	2.50	4.25	4.17
23	7.08	11.50	6.67	5.50	2.13	5.42	2.00	2.00	2.08	3.25	4.17	3.83
24	9.17	10.25	8.08	5.17	2.25	6.17	2.00	3.08	2.08	4.67	4.08	3.92
25	9.50	9.00	10.33	5.00	2.33	5.58	4.33	6.50	2.00	4.17	5.42	4.58
26	9.42	8.25	10.83	4.75	2.29	4.58	4.00	6.58	1.92	3.67	6.42	6.33
27	8.42	11.33	10.08	4.67	2.25	4.33	3.83	5.25	1.83	3.17	6.17	8.25
28	7.50	13.08	8.92	4.25	2.21	3.75	3.33	5.67	1.75	3.00	5.42	9.33
29	7.00	.....	7.83	4.08	2.17	3.50	3.00	6.00	1.75	2.83	5.00	8.58
30	7.08	.....	7.50	3.83	2.08	3.50	2.75	5.33	1.75	2.67	4.67	7.83
31	9.83	.....	7.67	.....	2.00	.....	3.92	5.17	.....	2.58	.....	8.50

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.50	2.83	4.50	9.75	3.00	5.92	4.67	1.92	2.92	1.08	0.50	1.92
2	8.25	2.92	4.00	9.00	2.83	5.50	4.33	2.00	2.50	1.25	.50	1.83
3	8.75	2.92	3.58	8.50	2.83	5.17	3.75	1.83	2.33	1.42	.50	1.75
4	9.33	3.08	3.25	11.75	2.83	7.58	3.67	2.00	2.17	1.25	.50	1.58
5	8.83	3.08	3.00	14.33	4.50	12.50	3.50	3.00	2.00	1.08	.50	1.58
6	8.00	3.00	2.67	14.67	5.83	12.00	3.58	2.83	1.83	1.08	.50	1.50
7	7.83	3.00	2.83	13.17	7.58	11.25	3.42	2.83	1.83	1.00	.50	1.50
8	6.83	2.92	2.83	11.83	7.58	9.00	3.42	3.00	1.75	1.00	.50	1.50
9	5.33	2.75	3.83	9.50	7.83	7.67	3.42	2.67	1.67	1.00	.75	1.58
10	5.67	2.50	5.25	7.83	6.67	7.00	3.00	2.42	1.50	1.00	.92	1.67
11	4.17	2.58	6.17	7.00	5.58	7.42	2.83	2.17	1.50	1.00	1.00	2.42
12	3.67	2.50	5.92	6.42	5.00	7.00	2.50	2.08	1.42	.92	1.17	4.25
13	3.75	2.00	5.67	5.67	4.75	6.42	2.17	2.42	1.42	.92	1.17	4.00
14	5.50	1.08	5.00	5.33	4.25	5.42	2.17	2.50	1.50	.83	1.17	3.50
15	11.83	1.75	4.42	4.75	4.17	4.67	2.33	3.50	2.33	.83	1.25	3.08
16	13.17	1.83	4.00	4.75	4.17	4.17	2.42	4.17	2.33	.83	1.25	2.83
17	10.83	1.67	3.50	4.33	4.42	3.75	2.42	4.00	2.08	.83	1.25	2.92
18	9.08	1.75	3.33	4.33	4.83	3.58	2.25	3.50	1.83	.83	1.25	2.67
19	7.75	2.00	3.08	4.00	4.92	3.50	2.25	2.83	1.67	.83	1.92	2.58
20	7.67	2.83	3.00	3.83	5.67	3.50	2.08	2.67	1.50	.83	2.50	2.50
21	7.00	2.17	2.92	3.67	7.25	3.67	2.00	2.33	1.50	.83	2.50	2.42
22	6.17	2.50	2.67	3.50	8.25	4.00	1.75	2.17	1.50	.83	2.92	2.08
23	5.33	2.67	2.50	3.42	8.83	3.67	1.67	1.92	1.33	.83	3.58	1.50
24	4.75	3.17	2.50	3.50	8.75	3.50	1.67	1.83	1.17	.83	3.33	.92
25	4.50	3.50	2.67	3.50	8.25	3.67	1.67	1.92	1.17	.75	2.92	1.08
26	4.33	4.33	3.50	3.58	7.33	4.17	1.58	2.17	1.25	.58	2.50	2.58
27	3.58	4.50	4.50	3.58	6.67	3.58	1.50	2.00	1.25	.58	2.08	2.00
28	2.50	4.83	10.83	3.50	6.50	3.25	1.50	2.00	1.25	.58	2.00	2.25
29	2.08	4.67	13.00	3.33	6.33	3.50	1.50	2.00	1.08	.58	2.00	2.25
30	2.83	.....	12.00	3.17	7.08	4.83	1.42	2.25	1.08	.58	1.92	2.25
31	2.83	.....	10.58	.....	6.42	.....	1.67	3.00	.....	.50	.....	2.17

Daily gage height, in feet, of Susquehanna River, at Harrisburg, Pennsylvania, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.67	2.58	6.08	4.92	3.67	2.33	0.92	3.58	2.00	2.17	4.00
2	2.50	3.00	2.58	6.00	4.83	3.67	2.17	.83	4.17	2.00	2.17	3.83
3	2.83	4.00	2.75	6.42	5.50	3.50	2.08	.83	3.92	1.83	2.17	3.67
4	2.83	4.17	2.75	7.50	6.83	3.58	1.92	.83	3.50	1.67	2.17	3.67
5	2.75	5.00	2.75	7.92	16.17	3.58	1.92	.75	2.67	1.50	2.33	3.67
6	2.67	5.08	2.50	8.92	16.50	3.17	1.67	.75	2.25	1.50	3.00	3.50
7	2.50	5.00	2.50	9.50	14.58	3.00	1.67	.67	2.00	1.42	3.25	3.17
8	2.50	5.33	2.67	8.83	12.00	3.00	1.58	.67	1.75	1.42	2.83	3.00
9	2.50	5.42	3.08	8.00	9.92	3.00	1.50	.58	1.67	1.42	2.75	3.00
10	2.50	6.42	6.50	8.42	8.25	2.83	1.50	.58	1.50	1.33	2.50	2.92
11	2.25	7.75	12.50	10.00	7.00	2.67	1.50	.50	1.50	1.33	2.50	2.83
12	2.25	11.58	13.83	9.42	6.17	2.58	1.50	.50	1.67	1.33	2.42	2.83
13	2.08	7.50	14.50	8.42	5.50	2.50	1.50	.42	2.00	1.25	2.33	2.83
14	2.08	6.50	14.58	7.75	5.00	2.33	1.50	.42	2.00	1.67	2.17	2.50
15	2.08	5.58	13.00	7.42	4.75	2.08	1.75	.42	1.83	4.67	2.08	2.00
16	2.00	5.25	12.25	8.08	4.58	2.00	1.83	.33	2.00	5.33	2.00	2.25
17	2.00	7.75	10.50	8.83	5.92	1.92	1.83	.33	2.50	5.25	1.92	2.42
18	2.00	6.75	8.83	8.92	8.50	1.83	1.67	.33	2.67	4.25	1.83	5.75
19	2.00	5.83	7.33	7.75	9.75	1.75	1.67	.33	4.42	3.83	1.75	8.83
20	2.00	5.33	6.67	6.92	9.00	1.75	1.67	.67	3.67	3.42	1.75	7.08
21	2.00	4.67	5.92	7.00	7.58	1.75	1.67	.58	3.25	3.00	1.67	6.00
22	2.00	4.25	5.58	10.00	7.00	1.58	1.50	.50	2.83	2.50	1.58	5.92
23	2.00	3.50	5.67	10.92	6.25	1.58	1.42	.42	2.50	2.50	1.58	4.42
24	2.00	3.00	6.83	10.50	5.58	1.75	1.33	.42	2.33	2.33	1.67	3.92
25	2.00	3.00	7.25	8.92	5.42	1.75	1.25	.33	2.33	2.25	1.67	3.83
26	2.00	3.00	7.75	7.67	4.92	2.00	1.17	.42	2.17	2.25	1.58	3.83
27	2.00	2.92	9.42	6.83	4.50	2.25	1.08	.50	2.00	2.25	1.58	4.83
28	2.00	2.75	8.67	6.17	4.33	2.50	1.08	.50	2.00	2.00	1.75	5.92
29	2.00	.....	7.83	5.67	4.17	2.75	1.83	1.00	2.00	2.00	2.83	5.83
30	2.33	.....	7.83	5.17	3.92	2.50	.92	3.00	2.00	2.00	3.67	5.17
31	2.50	.....	6.50	.....	3.67	.....	.92	3.08	.....	2.17	.....	4.67

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	2.41	3.16	3.83	4.58	9.50	2.58	1.08	0.33	1.91	5.08	2.41
2	4.5	2.33	3.33	3.66	4.50	9.66	2.41	1.08	.33	1.83	5.25	2.33
3	4.0	2.25	3.50	3.50	4.16	9.16	2.33	1.33	.33	1.58	5.41	2.50
4	3.66	2.16	3.75	3.25	3.83	8.58	2.25	1.50	.33	1.58	7.50	2.91
5	3.5	2.08	4.08	3.16	3.50	8.41	2.00	1.66	.25	1.41	7.66	3.50
6	3.33	2.00	5.66	3.00	3.16	7.91	2.00	1.58	.25	1.41	7.58	3.58
7	3.41	2.00	7.66	2.91	3.25	6.75	1.83	1.50	.33	1.33	7.16	3.58
8	5.16	2.00	11.33	2.83	3.33	6.00	1.83	1.50	.33	1.33	7.00	3.33
9	5.25	2.08	12.16	2.75	3.50	5.50	1.75	1.08	.41	1.25	6.50	3.00
10	4.58	3.50	10.83	2.75	3.50	5.00	1.66	1.08	1.00	1.33	6.00	3.00
11	3.75	5.00	8.50	2.83	3.50	4.66	1.58	1.08	1.91	2.08	5.50	3.33
12	3.33	6.00	9.83	3.00	3.08	4.00	1.50	1.00	1.50	4.91	5.33	4.00
13	2.50	5.66	7.16	3.25	2.91	3.75	1.41	1.00	1.33	5.58	4.66	4.33
14	3.16	4.58	7.00	3.66	2.75	3.66	1.41	1.00	1.25	5.08	4.50	5.75
15	3.16	4.33	6.41	6.33	2.50	3.66	1.33	1.00	1.25	4.66	4.00	6.16
16	2.83	3.66	5.83	7.58	2.50	3.58	1.33	1.00	1.16	4.16	3.91	6.33
17	2.66	3.33	5.50	9.08	2.33	3.41	1.25	1.00	1.08	3.83	3.66	5.75
18	2.83	3.33	5.08	9.08	2.33	3.16	1.16	1.00	1.08	3.66	3.50	5.16
19	2.83	3.33	4.83	8.50	2.33	3.00	1.08	.91	2.16	3.41	3.25	4.66
20	3.00	4.16	4.58	7.50	5.33	3.50	1.08	.91	4.08	3.00	3.16	4.33
21	2.83	5.66	4.50	6.75	16.33	3.41	1.08	.83	5.00	2.75	3.08	4.08
22	2.83	5.33	4.33	8.50	25.58	3.08	1.08	.83	5.50	2.50	3.25	3.83
23	2.58	5.16	4.50	9.41	21.41	2.83	1.00	.75	5.66	2.33	3.16	3.58
24	2.41	4.33	4.66	9.58	15.25	2.50	1.08	.75	4.83	2.16	3.00	3.50
25	2.41	3.33	5.50	9.91	11.83	2.50	1.25	.75	4.00	2.33	3.00	3.33
26	2.41	2.91	7.00	9.00	11.33	2.66	1.41	.75	3.41	3.58	2.83	3.08
27	2.41	2.33	6.33	7.25	11.66	2.58	1.50	.66	3.00	4.75	2.66	3.00
28	2.50	2.50	5.50	6.00	9.50	2.66	1.50	.66	2.58	4.83	2.58	3.00
29	2.58	.....	4.91	5.41	7.91	2.41	1.41	.58	2.25	4.33	2.58	4.00
30	2.58	.....	4.33	5.00	7.00	2.75	1.16	.50	2.08	4.00	2.50	3.66
31	2.50	.....	4.00	.....	7.50	.....	1.08	.41	.....	3.75	.....	3.66

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.92	2.92	6.00	5.75	3.42	2.67	2.83	0.58	0.75	0.42	0.21	3.08
2	4.00	2.83	8.58	5.67	3.33	2.58	2.67	.67	.75	.42	.21	3.08
3	4.25	3.00	8.08	6.17	3.25	2.50	2.92	.67	.67	.33	.25	2.75
4	4.33	3.00	10.50	6.83	3.00	2.25	2.50	.67	.67	.33	.25	2.50
5	4.33	7.00	7.83	6.67	2.75	2.08	2.25	.58	.58	.33	.33	2.25
6	4.33	5.67	7.67	6.17	2.67	1.92	2.00	.50	.58	.33	.38	2.00
7	4.33	5.75	6.67	6.00	2.50	1.83	1.92	.50	.75	.33	.38	1.92
8	4.50	5.67	6.25	5.75	2.42	1.75	1.75	.83	.75	.25	.42	1.92
9	4.75	5.50	5.83	8.08	2.25	1.75	1.58	.75	.67	.25	.42	1.92
10	6.17	5.50	6.17	12.00	2.75	1.58	1.50	1.00	.50	.21	.42	1.83
11	7.42	5.58	6.17	13.67	3.00	1.33	1.50	1.08	1.00	.21	.42	.50
12	7.83	5.92	6.33	12.50	3.33	1.42	1.42	1.08	1.50	.21	.46	1.50
13	8.50	5.83	6.17	10.92	3.67	1.33	1.33	1.08	1.58	.33	.50	.96
14	7.83	5.83	6.00	9.50	4.33	1.25	1.33	.92	1.42	.29	.58	.75
15	6.75	5.67	6.50	10.00	4.33	1.25	1.25	1.33	1.00	.29	.58	1.00
16	6.25	5.58	6.75	9.75	4.17	1.25	1.25	1.33	.83	.25	.58	1.00
17	5.75	5.50	6.67	8.75	4.08	1.25	1.08	1.08	.67	.25	.67	1.33
18	5.42	5.50	6.33	7.58	3.67	1.25	1.00	1.00	.58	.42	.83	1.33
19	5.00	5.33	5.67	6.67	3.50	1.25	.92	1.00	.67	.58	1.00	1.33
20	4.50	5.25	5.50	6.00	3.33	1.25	.92	.92	.67	.50	1.00	1.33
21	4.42	5.17	5.33	5.50	3.17	1.17	.83	.83	.67	.42	.92	1.50
22	4.33	5.08	5.17	5.00	3.08	1.00	.83	.58	.58	.42	.79	1.83
23	4.00	5.00	5.00	4.58	2.92	.75	.83	.50	.58	.33	.67	2.00
24	4.00	4.92	5.00	4.33	2.75	.75	.83	.50	.58	.25	.75	2.67
25	3.33	4.75	5.00	4.00	2.58	.75	.83	.42	.58	.25	.75	2.75
26	3.25	4.58	5.83	3.75	2.50	1.50	.83	.33	.50	.21	.75	2.83
27	3.08	4.50	8.00	3.58	2.50	1.50	.83	.33	.50	.13	.75	3.33
28	3.08	4.75	9.00	3.75	2.42	1.50	.83	.33	.42	.08	2.67	3.50
29	3.08	.....	8.00	3.75	2.42	2.00	.75	.33	.42	.08	2.83	5.08
30	3.25	.....	7.17	3.50	3.08	3.50	.58	.33	.42	.04	2.83	5.67
31	3.00	.....	6.33	.....	3.00	.....	.42	.50	.....	.04	.....	5.67

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.92	4.50	7.17	14.58	3.00	1.50	2.67	4.67	0.33	5.42	2.08	3.92
2	9.17	3.75	9.17	14.58	3.00	1.50	2.42	4.33	.33	4.25	1.92	3.92
3	8.42	3.58	9.75	13.75	2.83	1.75	2.08	3.83	.33	4.00	1.83	3.83
4	6.50	3.58	8.42	12.83	2.83	1.83	1.83	3.75	.33	3.17	1.83	3.33
5	5.08	3.50	7.17	10.50	2.67	1.67	1.75	3.67	.25	2.67	1.83	3.00
6	4.00	4.00	5.50	8.83	2.50	1.67	1.67	3.58	.25	2.08	7.25	2.75
7	3.83	11.50	5.00	7.25	2.42	1.67	2.17	2.50	.25	1.83	10.08	2.67
8	3.00	12.50	4.75	6.50	2.17	1.58	2.00	2.33	.25	1.67	7.75	2.50
9	4.67	10.33	4.50	6.17	2.08	1.42	1.92	2.33	.25	1.50	6.50	2.50
10	4.33	8.50	4.83	5.83	2.00	1.75	2.33	2.25	.25	1.50	5.67	2.67
11	4.08	6.83	5.08	5.50	2.00	2.50	2.75	2.25	.25	1.50	4.75	3.42
12	4.00	5.33	4.67	5.50	1.92	2.58	2.75	2.00	.25	1.50	4.42	3.75
13	3.92	4.92	4.00	6.00	1.75	3.42	2.50	1.83	.25	1.92	4.17	4.00
14	4.00	4.25	3.50	6.42	1.67	3.25	2.17	1.67	.33	7.33	4.00	4.25
15	3.83	3.75	2.67	8.00	1.67	2.92	2.00	1.67	.33	7.00	3.83	3.83
16	3.83	3.75	2.67	8.42	1.75	2.58	1.83	1.58	.33	9.50	3.67	3.67
17	3.75	3.83	2.33	8.17	1.58	2.58	1.67	1.58	.50	7.67	3.50	3.42
18	3.58	3.58	2.50	7.33	1.50	2.83	1.58	1.58	.50	5.58	3.33	3.08
19	3.67	2.92	3.17	6.83	1.50	2.67	1.67	1.33	.58	4.83	3.17	2.92
20	4.00	3.00	4.00	6.33	1.50	3.00	1.67	1.25	.58	4.08	3.00	2.58
21	3.67	2.83	6.00	5.75	1.50	3.17	1.92	1.00	.67	3.58	2.83	2.33
22	3.50	3.67	5.75	5.25	1.42	3.00	1.67	.83	.83	3.42	2.67	2.00
23	3.50	5.42	5.75	4.83	1.42	2.42	1.58	.83	1.17	3.25	2.58	2.00
24	3.50	5.42	6.25	4.58	1.42	2.33	1.67	.83	1.17	3.00	2.50	1.50
25	4.00	3.42	5.58	4.33	1.33	2.25	1.67	.83	.92	3.00	2.50	1.50
26	7.25	3.50	5.00	4.08	1.25	2.67	1.75	.75	.75	3.00	2.33	1.50
27	7.33	3.67	5.25	4.00	1.17	4.75	1.92	.75	.58	2.75	2.33	1.50
28	6.17	3.17	6.08	3.58	1.25	4.00	2.50	.67	.50	2.67	2.42	1.50
29	6.00	3.17	6.50	3.42	1.50	3.50	2.50	.58	.42	2.50	2.67	1.33
30	5.75	.....	9.25	3.25	1.50	3.08	3.75	.50	.83	2.42	3.50	1.58
31	5.42	.....	12.50	.....	1.50	.....	4.33	.33	.....	2.23	.....	1.75

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.83	3.33	4.25	5.00	3.08	2.92	1.42	4.00	1.25	1.75	0.67	5.00
2	2.00	3.17	3.67	4.67	3.08	2.83	1.33	4.33	1.08	1.50	1.17	4.50
3	2.00	3.17	3.25	4.33	5.50	2.67	1.25	3.83	1.00	1.33	3.08	4.00
4	2.08	3.17	3.83	4.17	6.50	2.58	1.25	3.25	1.00	1.17	4.08	3.75
5	2.50	3.08	4.92	4.00	7.50	2.67	1.25	2.83	1.00	1.08	3.50	3.33
6	3.00	3.00	5.92	3.83	7.08	3.00	1.25	2.67	.92	1.00	3.08	4.75
7	3.67	4.25	7.67	3.75	7.00	2.67	1.42	2.42	.83	1.00	3.00	5.17
8	3.67	7.50	8.58	3.75	6.33	2.50	1.42	2.67	.83	.92	2.75	5.08
9	3.67	6.58	8.00	3.75	5.50	2.67	1.25	2.50	.83	.83	2.50	5.42
10	3.33	5.42	6.92	5.92	4.83	2.67	1.25	2.08	.83	.67	2.50	4.92
11	3.08	4.83	6.50	9.00	4.50	2.67	1.17	2.08	.75	.67	2.67	4.33
12	2.83	4.50	7.25	9.50	4.00	2.67	1.08	2.00	.67	.58	2.67	4.17
13	2.42	3.92	8.67	8.00	4.00	3.00	1.00	1.83	.67	.75	2.50	4.17
14	2.00	3.83	8.42	6.83	6.00	3.50	1.08	1.75	.67	.75	2.50	4.33
15	2.00	3.83	7.75	6.00	7.75	3.25	1.00	1.58	.50	.75	2.50	4.58
16	2.00	3.50	7.00	6.00	7.92	2.92	1.00	1.58	.58	.75	2.50	6.58
17	2.00	3.50	6.92	6.58	7.33	2.67	1.17	1.50	.67	.67	2.50	7.67
18	2.17	3.33	5.50	7.00	6.50	2.50	1.17	1.50	.75	.67	2.67	8.17
19	2.33	3.58	5.00	6.58	5.75	2.25	1.08	1.42	.75	.58	2.92	7.33
20	2.00	4.08	5.33	6.00	5.00	2.17	1.08	1.42	.67	.58	3.42	6.33
21	1.83	4.00	7.42	5.50	4.25	2.17	1.50	1.33	.58	.50	3.25	5.58
22	1.83	4.25	8.25	4.92	4.00	2.17	1.50	1.17	.58	.58	3.17	5.00
23	1.92	5.92	9.75	4.50	3.58	2.00	1.33	1.17	.58	.75	2.83	4.08
24	1.67	7.92	9.50	4.17	3.50	1.83	1.33	1.25	1.00	.75	2.50	3.83
25	1.67	7.50	10.17	3.83	3.75	1.75	1.58	1.67	1.50	1.00	2.50	3.42
26	.50	6.50	11.50	3.67	3.75	1.75	1.75	2.67	1.50	1.00	2.50	2.83
27	3.33	5.50	10.67	3.58	3.50	1.67	1.75	2.08	1.83	1.00	2.33	2.75
28	3.33	4.50	8.00	3.50	3.58	1.58	2.17	1.75	1.92	.92	2.50	2.67
29	3.00	.....	7.42	3.33	3.92	1.58	3.83	1.58	2.25	.83	3.50	2.67
30	3.25	.....	6.33	3.17	3.50	1.50	4.50	1.50	2.00	.75	4.92	2.58
31	3.33	.....	5.58	.....	3.25	.....	4.08	1.33	.....	.75	.....	2.50

ROWLANDSVILLE STATION ON OCTORARO CREEK.

This station, described on page 16 of the Eighteenth Annual Report of this Survey, Part IV, was established November 21, 1896, at the wagon bridge in the village of Rowlandsville, Maryland. A wire gage was attached to the floor timber on the upper side of the bridge. The observer is Hugh W. Caldwell. The bench mark for the gage is a cross cut in top of capstone on the lower side of the bridge abutment on the left bank of the stream, and is 18.83 feet above the zero of the gage. Observations of height of water were begun at this point on November 22, 1896, the height during the remainder of that year ranging from 3 to 3.20 feet, except in the case of a flood on November 29 rising to 4.30 feet. The following measurements have been made by Hugh W. Caldwell:

November 21, 1896, gage height, 3.00 feet; discharge, 138 second-feet.
January 23, 1897, gage height, 3.42 feet; discharge, 248 second-feet.
July 21, gage height, 3.45 feet; discharge, 264 second-feet.
August 16, gage height, 3.10 feet; discharge, 175 second-feet.
August 31, gage height, 2.80 feet; discharge, 138 second-feet.
September 18, gage height, 2.90 feet; discharge, 136 second-feet.
October 22, gage height, 3.10 feet; discharge, 138 second-feet.
November 2, gage height, 6.00 feet; discharge, 1,843 second-feet.
November 3, gage height, 4.00 feet; discharge, 444 second-feet.

Daily gage height, in feet, of Octoraro Creek at Rowlandsville, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.20	3.45	3.30	3.40	3.40	3.00	3.40	2.80	2.80	3.10	3.30
2	3.10	3.20	3.60	3.30	3.40	3.40	3.00	3.30	2.80	2.80	6.00	3.40
3	3.10	4.80	3.50	3.30	3.60	3.40	3.00	3.30	2.80	2.80	4.15	3.45
4	3.10	3.55	3.50	3.30	3.50	3.40	3.00	3.30	2.80	2.80	3.70	3.60
5	3.15	3.45	3.50	3.30	3.46	5.45	3.00	3.30	2.80	2.80	3.40	4.35
6	3.10	3.68	3.45	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.40	3.70
7	3.10	10.10	3.40	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.30	3.45
8	3.10	9.20	3.40	3.30	3.30	3.45	2.90	3.20	2.80	2.80	3.65	3.30
9	3.10	7.50	3.30	4.60	3.20	3.40	2.90	3.30	2.80	2.80	3.50	3.30
10	3.10	5.40	3.30	5.50	3.20	3.30	2.90	3.30	2.80	2.80	3.60	3.30
11	3.10	3.50	3.30	6.15	3.20	3.30	2.90	5.10	2.80	2.90	3.70	3.60
12	3.10	3.35	3.20	5.65	3.20	3.30	2.90	3.40	2.80	2.85	3.45	3.40
13	3.10	3.30	3.20	4.55	4.85	3.30	2.90	3.30	2.80	2.80	3.35	3.30
14	3.10	3.30	3.20	3.85	5.00	3.20	2.90	3.20	2.80	2.80	3.30	4.65
15	3.10	3.40	3.20	3.60	5.00	3.20	2.90	3.10	2.80	2.80	3.20	4.90
16	3.10	4.55	3.20	3.50	3.75	3.20	2.90	3.10	2.80	2.80	3.20	3.95
17	3.10	4.05	3.20	3.50	3.55	3.20	2.90	3.10	3.05	2.80	3.20	3.70
18	3.10	3.55	3.40	3.45	3.40	3.20	2.90	3.00	2.90	2.80	3.30	3.60
19	3.10	3.60	4.15	3.45	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.60
20	3.10	3.40	3.60	3.40	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.50
21	6.70	3.45	3.40	3.30	3.40	3.20	3.75	3.05	2.80	3.00	3.20	3.50
22	6.65	3.45	3.40	3.30	3.65	3.20	3.85	3.05	2.80	3.05	3.20	3.40
23	4.45	6.00	3.40	3.20	3.40	3.10	3.55	3.00	3.20	3.20	3.20	3.30
24	3.30	3.80	4.20	3.20	3.40	3.10	3.40	3.00	3.20	3.20	3.20	3.30
25	3.20	3.45	3.95	3.20	5.05	3.10	3.30	3.00	3.10	3.20	3.20	3.30
26	3.20	3.35	3.55	3.20	4.80	3.10	3.30	3.00	3.00	3.20	3.20	3.35
27	3.20	3.40	3.40	3.20	3.90	3.10	4.25	2.90	3.00	3.20	4.85	3.50
28	3.20	3.40	3.30	3.20	3.50	3.10	3.05	2.90	3.00	3.10	4.10	3.50
29	3.20	.....	3.30	3.20	3.40	3.00	3.65	2.80	2.90	3.10	3.65	3.40
30	3.20	.....	3.30	3.20	3.40	3.00	3.50	2.80	2.80	3.00	3.40	3.40
31	3.20	.....	3.30	.....	3.40	.....	3.40	2.80	.....	3.00	.....	3.50

WOODSTOCK STATION ON PATAPSCO RIVER.

This station, described on page 16 of the Eighteenth Annual Report, Part IV, is located on the county bridge on the road from Woodstock to Granite, Maryland, a mile and a half below the junction with the North Branch. The pulley of the wire gage is fastened to the floor timber of the upper side of the bridge 40 feet from the initial point established for making soundings. The scale is a board spaced to tenths of a foot with small nails and nailed to the guard timber of the bridge. The channel at this point is rough and rocky, and is also liable to change in extreme high water. The bench mark is a United States Geological Survey standard copper bolt set in the face of the retaining wall of the entrance to the college grounds at the north end of the bridge. It is 22.06 feet above gage datum. The gage wire was renewed October 14, 1897. The observer is David Donovan.

The following measurements were made by E. G. Paul in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 10	4.20	345	July 13	4.20	397	July 22	6.10	2,417
Mar. 9	4.10	297	July 20	3.80	239	Oct. 14	3.35	151
Apr. 10	4.60	582	July 22	9.30	5,466	Nov. 29	3.50	202
May 13	7.30	2,934	July 22	8.10	4,139	Dec. 15	4.70	714

Daily gage height, in feet, of Patapsco River at Woodstock, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	3.60	4.05	3.85	3.90	4.05	3.75	3.85	3.35	3.20	3.80	3.80
2	3.70	3.60	4.05	3.85	4.00	4.05	3.75	3.95	3.25	3.25	10.70	3.75
3	3.50	5.00	4.15	3.90	4.15	4.20	3.75	3.95	3.30	3.15	3.75	3.75
4	3.60	4.60	4.05	3.70	4.30	4.15	3.70	3.75	3.20	3.15	4.00	4.05
5	3.85	4.70	4.05	4.70	4.25	5.05	3.70	3.70	3.35	3.25	3.85	5.00
6	3.90	9.60	4.15	4.40	4.10	4.05	3.75	3.75	3.30	3.20	3.80	4.35
7	3.90	6.45	4.15	4.15	4.00	.....	3.75	3.70	3.20	3.30	3.70	4.10
8	3.85	4.70	4.05	4.15	4.00	4.15	3.90	3.50	3.05	3.05	3.80	4.05
9	3.95	4.50	4.05	4.80	3.85	4.25	3.80	3.65	3.15	3.15	4.10	3.95
10	3.85	4.45	4.05	4.50	3.85	4.00	3.65	7.30	3.15	3.00	3.80	3.95
11	3.80	4.20	4.05	4.50	3.90	3.95	3.65	4.55	3.10	3.05	3.80	3.95
12	3.85	4.20	4.00	4.30	4.15	3.95	7.05	3.90	2.95	3.05	3.80	4.50
13	3.85	4.05	4.05	4.10	6.60	4.05	4.45	3.90	3.35	3.20	3.70	4.10
14	3.80	4.05	4.05	4.15	5.00	3.95	4.25	3.90	3.20	3.40	3.65	4.80
15	3.65	4.20	4.15	4.30	4.85	3.90	4.00	3.80	3.10	3.35	3.80	5.55
16	3.70	4.50	4.15	4.30	4.35	3.90	3.70	6.05	3.15	3.30	3.75	4.50
17	3.80	4.30	4.05	4.10	4.30	3.90	4.10	4.00	3.25	3.15	3.70	4.30
18	3.85	4.25	3.95	4.30	4.20	3.95	4.15	3.95	3.45	3.35	3.70	4.15
19	3.80	4.05	4.00	4.05	4.20	3.90	4.00	3.85	3.30	3.30	3.65	4.05
20	3.75	4.05	4.75	4.05	4.20	3.90	3.90	3.75	3.30	3.35	3.60	4.10
21	3.90	4.55	4.35	3.90	4.15	3.90	3.80	3.70	3.30	3.50	3.60	4.00
22	4.45	5.95	4.15	3.90	4.15	3.75	7.50	3.85	3.20	3.35	3.65	4.00
23	8.50	5.80	4.20	3.90	3.95	3.70	4.30	4.00	3.25	3.50	3.85	3.90
24	3.95	4.75	4.40	3.90	5.77	3.75	3.90	7.15	3.30	3.15	3.80	3.60
25	3.95	4.40	4.20	3.85	4.63	3.75	3.80	4.00	3.35	3.55	3.60	3.90
26	4.05	4.30	4.10	3.95	4.20	3.80	3.80	4.70	3.25	3.70	3.60	4.00
27	3.60	4.35	4.10	3.90	4.15	3.70	4.25	4.00	3.40	3.45	4.55	4.00
28	3.60	4.10	4.05	3.90	4.15	3.80	6.65	3.50	3.20	3.40	3.90	3.80
29	3.60	.....	3.95	3.80	4.05	3.75	5.10	3.25	3.25	3.40	3.85	3.80
30	3.60	.....	3.90	3.80	3.85	3.70	4.10	3.40	3.20	3.35	3.85	3.80
31	3.60	.....	3.95	.....	4.55	.....	4.00	3.45	.....	3.15	.....	3.90

LAUREL STATION ON PATUXENT RIVER.

This station, described on page 18 of the Eighteenth Annual Report of this Survey, Part IV, was established August 3, 1896, on the bridge on the main cross street of the town of Laurel, Maryland. The initial point for soundings is the end of iron truss, upper side. A wire gage with metal weight was attached to the lower side of the bridge, the scale being a 14-foot board spaced to tenths of a foot with small nails and fastened to the floor timber of the bridge. The bench mark is a copper bolt set in large capstone of the retaining wall on the lower side of the bridge abutment on the left bank of the stream. It is 21.22 feet above zero of gage height. The flow of water past this station in time of dry weather is confined to certain hours of the day, owing to a dam at the large cotton mill situated about 1 mile up the stream from the station. The observer is John H. Phair.

The following discharge measurements were made by E. G. Paul and others during 1897:

February 11, gage height, 5.40 feet; discharge, 184 second-feet.
February 23, gage height, 8.50 feet; discharge, 612 second-feet.
March 12, gage height, 4.40 feet; discharge, 155 second-feet.
May 25, gage height, 8.70 feet; discharge, 734 second-feet.
July 13, gage height, 7.85 feet; discharge, 539 second-feet.
July 22, gage height, 13.70 feet; discharge, 6,144 second-feet.
September 3, gage height, 4.10 feet; discharge, 63 second-feet.

Daily gage height, in feet, of Patuxent River at Laurel, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	5.15	5.15	4.65	4.85	4.80	4.50	5.60	4.20	4.15	4.55	4.95
2	4.90	5.75	5.05	4.65	5.75	4.80	4.35	5.05	4.20	4.25	10.50	4.90
3	3.90	9.10	5.00	4.60	4.85	4.80	3.80	4.75	4.20	3.25	6.30	4.85
4	4.75	7.50	4.85	4.60	4.85	5.05	6.60	4.60	4.00	4.45	5.35	5.50
5	4.70	6.30	5.00	5.20	4.75	5.10	3.55	4.85	4.00	4.30	4.95	7.80
6	4.75	9.05	5.10	5.30	4.80	4.45	3.85	4.65	4.00	4.10	4.85	5.65
7	4.55	10.80	(a)	4.95	4.75	4.75	3.80	4.30	4.00	3.60	4.65	5.35
8	4.45	7.95	(a)	4.85	4.45	4.75	4.65	4.30	3.95	4.30	5.00	5.10
9	4.05	5.50	(a)	6.50	4.25	5.00	4.45	4.40	3.95	4.25	5.55	5.15
10	3.75	5.25	(a)	6.35	4.65	4.75	4.40	4.40	3.80	3.45	5.75	4.85
11	4.20	5.30	(a)	5.00	4.70	4.55	3.70	4.35	3.80	4.45	4.95	4.85
12	4.45	5.30	4.50	5.00	4.85	4.20	4.60	4.35	4.15	4.60	5.00	4.80
13	4.60	5.30	4.95	4.95	7.65	4.20	8.10	4.30	4.25	4.60	4.95	5.15
14	4.90	5.10	4.75	4.90	7.35	4.50	5.05	4.20	4.55	4.55	4.45	5.55
15	5.15	6.30	5.20	4.85	5.85	4.70	4.60	4.20	4.05	4.25	5.00	8.70
16	4.25	6.35	4.70	5.05	5.40	4.00	4.25	3.15	3.60	4.15	4.90	6.05
17	3.70	6.35	4.95	4.95	4.85	4.50	4.25	4.60	3.80	3.15	4.70	5.50
18	4.25	5.35	5.45	4.75	5.00	4.45	4.80	4.35	4.60	4.35	4.90	4.35
19	4.75	5.15	5.45	4.75	4.80	4.30	5.55	4.30	3.30	4.25	4.75	4.90
20	4.65	5.05	5.65	4.65	4.50	4.15	6.00	4.20	4.15	4.15	4.75	5.00
21	4.70	4.80	5.50	4.65	4.80	4.55	4.75	4.15	4.35	4.75	4.40	4.95
22	5.20	8.65	5.20	4.80	5.05	4.40	12.25	7.30	4.30	4.45	4.70	5.15
23	5.00	9.10	5.00	4.45	4.50	4.45	6.45	4.60	4.50	4.45	4.75	5.00
24	4.25	6.55	5.05	3.90	5.30	4.40	5.50	4.70	5.90	3.95	4.55	5.15
25	4.00	5.60	5.15	4.40	9.75	4.00	4.95	4.45	4.50	4.55	4.45	5.10
26	4.75	5.30	4.95	4.55	5.25	4.35	5.15	6.90	3.90	4.90	4.80	5.25
27	5.00	5.20	4.70	4.60	5.30	3.70	5.45	4.45	4.50	4.70	9.60	4.95
28	4.05	4.85	4.50	4.60	4.90	4.55	9.20	4.35	4.25	4.70	5.45	4.60
29	5.20	.....	4.75	4.80	4.65	4.50	5.90	4.20	4.30	4.45	5.30	4.75
30	5.20	.....	4.80	4.55	4.35	4.40	5.30	4.20	4.15	4.45	4.95	5.00
31	4.25	.....	4.50	.....	4.80	.....	4.95	4.90	.....	3.60	.....	4.95

a Gage down.

CUMBERLAND STATION ON POTOMAC RIVER.

This station, described on page 22 of the Eighteenth Annual Report of this Survey, Part IV, is 1,000 feet below the mouth of Wills Creek at Cumberland, Maryland. The river gage consists of a vertical rod 10 feet long, bolted to the east side of the abutment of the head gate of the eastern feeder of the Chesapeake and Ohio Canal just above the dam. The top of the rod, or the 10-foot mark, is 5.40 feet below the top of the abutment. Measurements of the river are made from the West Virginia Central Railroad bridge, about 200 yards below the dam across the Potomac. At high water the section is fairly smooth and the velocity high. At low water, rocks, riffles, and angular currents appear. Measurements of the canal feeders have also been made near the head gates.

The following discharge measurements were made by A. P. Davis, E. G. Paul, and G. H. Matthes during 1897:

February 10, gage height, 3.75 feet; discharge, 1,307 second-feet.
March 27, gage height, 3.93 feet; discharge, 1,995 second-feet.
June 25, gage height, 3.00 feet; discharge, 425 second-feet.
September 1, gage height, 2.60 feet; discharge, 86 second-feet.
September 22, gage height, 2.70 feet; discharge, 92 second-feet.

Daily gage height, in feet, of Potomac River at Cumberland, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	3.40	4.00	3.50	3.50	2.90	2.70	3.00	2.60	2.20	2.80	.....
2	3.20	3.50	3.80	3.40	7.50	2.80	2.70	3.00	2.50	2.00	3.00	.....
3	3.30	3.60	3.90	3.40	5.50	2.80	2.70	2.90	2.50	1.90	3.00	.....
4	3.30	3.40	5.20	3.70	5.00	2.80	2.70	2.90	2.50	1.70	3.10	.....
5	4.00	3.40	4.90	3.80	4.60	2.80	2.70	3.50	2.40	1.70	3.00	.....
6	4.00	3.50	6.00	3.70	4.10	2.80	2.60	3.20	2.40	1.60	2.90	.....
7	3.70	4.50	5.00	3.60	4.10	2.80	2.60	3.10	2.20	1.50	2.90	.....
8	3.40	4.20	4.40	5.20	3.90	2.80	2.70	3.20	1.90	1.40	3.00	.....
9	3.30	4.00	4.60	5.40	3.70	2.90	2.70	3.10	1.80	1.40	4.00	.....
10	3.40	3.70	4.20	4.50	3.70	2.70	2.70	3.00	1.80	1.50	3.40	.....
11	3.20	3.60	4.00	4.50	3.60	2.70	2.80	3.00	1.70	1.30	3.40	.....
12	3.20	3.50	4.00	4.10	4.00	2.70	2.90	2.90	1.60	1.30	3.30	.....
13	3.20	3.70	3.90	4.00	4.40	2.60	2.90	2.90	1.50	1.30	3.20	.....
14	3.20	4.00	3.80	3.80	5.40	2.50	2.80	2.80	1.40	1.40	3.20	.....
15	3.20	4.20	4.00	3.90	4.60	2.50	2.80	3.00	1.30	1.50	3.50	.....
16	3.20	4.70	3.80	3.90	4.30	3.00	2.80	3.00	1.20	1.50	3.50	.....
17	3.40	4.50	3.70	3.70	3.90	3.00	2.70	2.90	1.20	1.40	3.40	.....
18	3.70	5.00	4.00	3.70	3.80	2.90	2.80	2.80	3.20	1.40	3.30	.....
19	3.50	4.80	4.50	3.60	3.70	2.90	2.80	2.90	3.00	1.40	3.30	.....
20	3.40	3.50	4.80	3.70	3.50	2.90	2.90	2.90	2.90	1.40	3.20	.....
21	3.40	3.50	4.60	3.50	3.30	3.00	3.20	2.90	2.80	1.40	.....	.....
22	3.50	10.50	4.20	3.30	3.30	3.00	3.00	2.90	2.70	1.30	.....	.....
23	3.40	8.70	4.00	3.30	3.30	2.90	3.00	2.90	2.60	1.30	.....	.....
24	3.40	6.20	4.20	3.30	3.00	2.90	3.00	2.90	2.80	1.50	.....	.....
25	3.30	5.10	4.10	3.20	3.00	3.00	3.00	2.90	3.00	1.60	.....	.....
26	3.30	4.50	4.00	3.10	3.00	2.90	2.90	3.00	3.00	1.60	.....	.....
27	3.30	4.30	3.90	3.00	3.00	2.90	3.20	3.00	2.90	1.70	.....	.....
28	3.30	4.00	3.80	3.00	3.00	2.90	3.10	3.00	2.80	1.70	.....	.....
29	3.30	.....	3.70	3.00	2.90	2.90	3.10	2.90	2.80	2.40	.....	.....
30	3.30	.....	3.60	2.90	2.90	2.80	3.10	2.80	2.70	2.70	.....	.....
31	3.30	.....	3.60	.....	2.90	.....	3.00	2.60	.....	2.70	.....	.....

SHARPSBURG STATION ON ANTIETAM CREEK.

The station is at Myers's mill, 1 mile east of Sharpsburg, Maryland, on the road to Keedysville, Maryland. It was established on June 24, 1897, by Arthur P. Davis. The observer is Evans M. Myers, a farmer living near the bridge. The equipment consists of a three-quarters inch steel cable with 85-foot span supported by large trees. The gage is driven into the gravel of the stream bed and bolted to an overhanging tree. The initial point for soundings is on the left bank. The channel both above and below the station is nearly straight for 300 feet, and the water moves with moderate velocity. The right bank is low and liable to overflow; the left is high and rocky. A measurement on June 24, 1897, with a gage height of 2.00 feet, gave a discharge of 251 second-feet; July 2, with a gage height of 2.05 feet, gave a discharge of 240 second-feet; September 3, with a gage height of 1.60 feet, gave a discharge of 122 second-feet; October 12, with a gage height of 1.70 feet, gave a discharge of 120 second-feet.

Daily gage height, in feet, of Antietam Creek at Sharpsburg, Maryland, from July to December, 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	1.90	1.50	1.70	1.50	1.45	1.70	17.....	1.75	1.80	1.60	1.60	1.70	2.20
2.....	2.10	1.70	1.70	1.60	2.70	1.60	18.....	1.70	1.70	1.60	1.40	1.60	2.10
3.....	1.85	1.70	1.60	1.40	2.05	1.60	19.....	1.75	1.60	1.60	1.50	1.50	2.00
4.....	1.70	1.75	1.60	1.60	1.90	1.70	20.....	1.75	1.50	1.50	1.70	1.60	2.10
5.....	1.75	1.60	1.50	1.70	1.60	2.25	21.....	1.85	1.50	1.60	1.70	1.70	2.00
6.....	1.80	1.70	1.70	1.60	1.60	2.15	22.....	1.85	1.55	1.60	1.60	1.60	2.00
7.....	1.70	1.70	1.70	1.70	1.70	2.05	23.....	1.70	1.60	1.70	1.60	1.50	2.10
8.....	1.70	1.50	1.60	1.60	1.75	2.00	24.....	1.70	3.00	1.90	1.65	1.70	2.50
9.....	1.70	1.40	1.65	1.50	1.80	1.80	25.....	1.55	2.90	1.80	1.65	1.80	2.20
10.....	1.70	1.70	1.60	1.40	1.60	1.90	26.....	1.65	2.00	1.50	1.80	1.80	2.00
11.....	1.55	1.90	1.60	1.50	1.55	1.90	27.....	1.75	1.75	1.70	1.70	1.90	2.00
12.....	1.75	1.85	1.50	1.60	1.50	1.90	28.....	1.80	1.70	1.60	1.60	2.00	1.90
13.....	1.95	1.60	1.40	1.70	1.60	2.05	29.....	1.85	1.55	1.60	1.60	1.90	1.80
14.....	1.80	1.70	1.50	1.50	1.40	2.00	30.....	1.80	1.80	1.50	1.60	1.80	1.80
15.....	1.80	2.45	1.60	1.60	1.50	2.35	31.....	1.70	1.70	.....	1.50	.....	1.90
16.....	1.80	1.90	1.70	1.65	1.75	2.40							

PORT REPUBLIC STATION ON NORTH AND SOUTH RIVERS.

This locality is described in the Eighteenth Annual Report of this Survey, Part IV, page 25. The gage for the North River is located on the county highway bridge at Port Republic, Virginia, and 500 feet above the mouth of South River. A painted rod is fastened to the third panel of the first span on the lower side of the bridge. It is nailed to the wooden uprights and fastened by wire to the iron diagonals. The zero of the rod is opposite the middle of the third upright, and is 4.50 feet from the outside edge of the pulley. The distance from the end of the weight to the marker is 31.98 feet. From the top of the lower end of the third floor beam from the right bank to the zero of the gage is 24.97 feet. The bridge seat on lower end of right-bank abutment is 24.60 feet above the datum of gage.

The gage for the South River is located on the county iron bridge, just east of the town, and 300 feet above the mouth of North River. It is a wire gage. The edge of the pulley is 2.54 feet from the north edge of the third vertical. The marks on the gage are made by tacks driven into the rail on the upper side of the bridge at the fourth panel. The zero is 1 foot from the edge of the pulley. The distance from the bottom of the weight to the wire marker or zero point is 26.12 feet. The top of the third floor beam from right bank, upper side of bridge, is 22.52 feet above gage datum. The zero of North River gage is 2.56 feet below the zero of South River gage. The observer is T. S. Davis.

All gagings of South River include discharge of mill race.

The following dicharge measurements were made by D. C. Humphreys and G. H. Matthes during the year 1897:

On North River:
March 23, gage height, 3.54 feet; discharge, 1,466 second-feet.
April 19, gage height, 2.60 feet; discharge, 712 second-feet.
June 1, gage height, 2.60 feet; discharge, 552 second-feet.
July 24, gage height 2.30 feet; discharge, 431 second-feet.
November 7, gage height, 2.00 feet; discharge, 245 second-feet.
On South River:
March 23, gage height, 2.30 feet; discharge, 426 second-feet.
April 19, gage height, 1.88 feet; discharge, 202 second-feet.
June 1, gage height, 1.87 feet; discharge, 182 second-feet.
July 24, gage height, 1.40 feet; discharge, 132 second-feet.
November 7, gage height, 1.80 feet; discharge, 173 second-feet.

Daily gage height, in feet, of North River at Port Republic, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.35	2.35	3.60	2.70	2.40	2.60	2.35	2.15	2.00	1.80	2.20	1.85
2	2.35	2.35	3.50	2.70	11.50	2.55	2.45	2.15	2.00	1.80	2.00	1.85
3	2.35	2.35	3.40	2.60	7.30	2.50	2.45	2.15	2.00	1.80	2.60	1.85
4	2.35	2.35	3.40	2.60	5.15	2.50	2.40	2.15	2.00	1.80	2.00	1.85
5	2.35	2.35	3.35	2.60	4.30	3.00	2.35	2.15	1.95	1.80	2.00	2.00
6	2.30	2.55	3.30	2.90	3.80	2.85	2.25	2.15	1.95	1.80	2.00	2.00
7	2.30	7.00	3.30	2.90	3.50	2.60	2.20	2.10	1.90	1.80	2.00	1.95
8	2.30	5.50	3.30	2.90	3.30	2.55	2.40	2.10	1.90	1.80	1.95	1.95
9	2.30	4.80	3.25	2.90	3.10	2.50	2.30	2.10	1.90	1.80	1.90	1.90
10	2.30	4.30	3.25	3.00	3.00	2.50	2.20	2.10	1.85	1.80	1.90	1.85
11	2.30	4.00	3.25	3.00	3.00	2.45	2.15	2.05	1.85	1.80	1.90	1.85
12	2.30	3.90	3.25	3.00	3.00	2.40	2.50	2.05	1.85	1.80	1.85	1.85
13	2.30	5.45	3.20	2.90	4.90	2.40	2.40	2.05	1.85	2.00	1.85	1.85
14	2.30	4.70	3.30	2.90	7.50	2.40	2.40	2.05	1.85	2.00	1.80	1.85
15	2.25	5.00	3.50	2.90	5.20	2.40	2.30	2.00	1.85	2.00	1.80	2.65
16	2.25	5.30	3.50	2.90	4.40	2.40	2.20	2.00	1.85	1.95	1.90	2.45
17	2.25	5.20	3.70	2.90	4.00	2.40	2.20	2.00	1.85	1.95	1.90	2.25
18	2.25	4.60	3.70	2.80	3.60	2.40	2.15	2.00	1.85	1.95	1.90	2.10
19	2.25	4.50	3.70	2.65	3.45	2.40	3.50	2.00	1.80	1.95	1.90	2.25
20	2.25	4.30	3.70	2.60	3.25	2.50	3.50	2.00	1.80	1.95	1.90	2.25
21	2.25	4.20	3.90	2.55	3.15	2.45	2.50	.....	1.80	2.00	1.85	2.25
22	2.25	4.80	3.60	2.50	3.10	2.40	2.40	2.00	1.80	2.00	1.85	2.25
23	2.25	9.85	3.35	2.50	3.00	2.40	2.35	2.00	1.80	2.00	1.85	2.25
24	2.25	6.70	3.40	2.50	2.95	2.40	2.35	2.00	1.80	2.00	1.85	2.25
25	2.25	5.40	3.30	2.50	2.90	2.40	2.30	2.00	1.80	2.00	1.85	2.25
26	2.25	4.50	3.20	2.50	2.85	2.40	2.25	2.00	1.80	2.00	1.85	2.25
27	2.25	4.40	3.10	2.45	2.80	2.35	2.20	2.00	1.80	2.00	1.85	2.25
28	2.25	3.80	3.00	2.45	2.75	2.35	2.15	2.00	1.80	2.10	1.85	2.25
29	2.25	.....	2.90	2.45	2.70	2.35	2.15	2.00	1.80	2.05	1.85	2.25
30	2.25	.....	2.80	2.40	2.65	2.35	2.15	2.00	1.80	1.95	1.85	2.20
31	2.35	.....	2.70	.....	2.60	.....	2.15	2.00	.....	1.95	.....	2.15

Daily gage height, in feet, of South River at Port Republic, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.45	1.85	2.60	2.00	1.75	1.85	1.60	1.50	1.20	1.30	1.75	1.50
2	1.45	1.85	2.50	2.00	9.30	1.80	1.65	1.50	1.20	1.30	2.80	1.50
3	1.45	1.85	2.40	2.00	4.50	1.75	1.65	1.50	1.20	1.30	2.50	1.50
4	1.45	1.85	2.40	2.00	3.30	1.75	1.60	1.50	1.20	1.30	2.10	1.50
5	1.45	1.85	2.35	2.00	3.00	1.90	1.55	1.50	1.20	1.30	2.00	1.50
6	1.45	1.95	2.30	2.10	2.80	1.75	1.55	1.50	1.20	1.30	2.00	1.50
7	1.45	5.00	2.30	2.10	2.50	1.70	1.55	1.50	1.20	1.30	1.80	1.50
8	1.45	4.10	2.30	2.10	2.50	1.65	1.55	1.45	1.20	1.30	1.75	1.50
9	1.45	3.20	2.25	2.10	2.40	1.60	1.55	1.40	1.20	1.30	1.70	1.50
10	1.45	3.05	2.25	2.10	2.30	1.55	1.55	1.40	1.20	1.30	1.70	1.50
11	1.45	2.95	2.25	2.00	2.30	1.50	1.55	1.40	1.20	1.30	1.70	1.50
12	1.45	2.90	2.25	2.00	2.30	1.50	1.55	1.40	1.30	1.30	1.65	1.50
13	1.45	3.15	2.20	1.90	3.20	1.65	1.50	1.40	1.30	1.45	1.65	1.50
14	1.45	3.15	2.30	1.90	4.80	1.65	1.50	1.40	1.30	1.45	1.65	1.50
15	1.45	3.15	2.40	1.90	3.20	1.65	1.50	1.35	1.30	1.45	1.65	1.45
16	1.45	3.40	2.60	1.90	2.85	1.65	1.50	1.35	1.30	1.45	1.65	2.40
17	1.45	3.40	2.60	1.90	2.70	1.60	1.50	1.35	1.30	1.45	1.65	2.00
18	1.45	3.20	2.60	1.85	2.50	1.60	1.50	1.30	1.30	1.45	1.65	1.90
19	1.45	3.20	2.60	1.85	2.40	1.60	1.70	1.25	1.30	1.45	1.65	1.90
20	1.45	3.10	2.60	1.80	2.35	1.65	1.60	1.20	1.30	1.45	1.65	1.85
21	1.45	3.10	2.70	1.80	2.30	1.80	1.55	1.20	1.30	1.50	1.60	1.80
22	1.45	3.60	2.50	1.80	2.25	1.70	1.50	1.20	1.30	1.50	1.55	1.80
23	1.45	6.75	2.30	1.80	2.20	1.65	1.50	1.20	1.30	1.50	1.55	1.80
24	1.65	4.10	2.35	1.80	2.20	1.60	1.50	1.20	1.30	1.50	1.55	1.80
25	1.85	3.30	2.25	1.80	2.20	1.60	1.45	1.20	1.30	1.50	1.50	1.80
26	1.85	3.20	2.15	1.80	2.15	1.60	1.40	1.20	1.30	1.50	1.50	1.80
27	1.85	3.10	2.05	1.80	2.15	1.60	1.40	1.20	1.30	1.50	1.50	1.80
28	1.85	2.80	2.10	1.80	2.10	1.60	1.40	1.20	1.30	2.00	1.50	1.80
29	1.85	.....	2.10	1.80	2.10	1.60	1.40	1.20	1.30	1.90	1.50	1.80
30	1.85	.....	2.10	1.75	2.00	1.60	1.40	1.20	1.30	1.85	1.50	1.80
31	1.85	.....	2.00	.....	1.95	.....	1.40	1.20	.....	1.75	.....	1.80

MILLVILLE STATION ON SHENANDOAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 26, is located at a point 4 miles above Harpers Ferry, at Millville, West Virginia. A vertical gage was placed in the river and secured to the trunk of a tree. A deep notch was cut in the tree opposite the 8-foot mark. Bench mark 2 is a copper bolt driven into an auger hole in the foot of a large sycamore (buttonwood) tree on the left bank of the river, about 150 feet below the gage rod, and it is 6.78 feet above the zero mark on the gage. A new three-fourths inch galvanized steel wire cable was stretched across the river on June 23, 1897, the old one having been carried out by the flood of October 1, 1896. The cable, which is about 500 feet long, is supported on either bank by a large sycamore tree, and is securely anchored on both sides. The observer is H. C. Nisewaner. The following discharge measurements were made by E. G. Paul and others, in 1897:

June 24, gage height, 1.20 feet; discharge, 1,371 second-feet.
July 23, gage height, 1.80 feet; discharge, 2,791 second-feet.
September 7, gage height, 0.50 foot; discharge, 632 second-feet.
October 25, gage height, 0.70 foot; discharge, 814 second feet.

Daily gage height, in feet, of Shenandoah River at Millville, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.10	3.70	2.00	1.40	1.50	1.00	1.00	0.60	0.40	0.80	0.70
2	1.50	1.10	3.50	2.00	1.70	1.50	.90	.90	.60	.40	.80	.70
3	1.40	1.60	3.50	1.90	9.25	1.40	.90	.80	.60	.40	.80	.60
4	1.40	2.00	3.50	1.90	7.10	1.60	.90	.80	.50	.40	1.00	.70
5	1.30	2.20	3.50	2.10	5.10	1.60	1.00	.80	.50	.40	1.30	.90
6	1.30	2.20	3.50	2.30	4.60	1.90	.90	1.40	.50	.40	1.00	1.70
7	1.30	(a)	3.40	2.30	3.60	1.80	.80	.90	.50	.35	.80	1.20
8	1.20	(a)	3.30	2.40	3.20	1.70	.80	.90	.50	.35	.80	1.10
9	1.20	(a)	3.00	2.40	2.90	1.60	.80	.90	.50	.35	.70	.90
10	1.10	6.00	2.80	2.40	2.50	1.60	.80	.80	.40	.35	.80	.90
11	1.10	5.20	2.70	2.40	2.40	1.40	.....	1.20	.40	.40	.70	.80
12	1.10	4.70	2.60	2.40	2.40	1.40	1.10	1.00	.40	.50	.70	.90
13	1.40	4.00	2.60	2.30	2.50	1.40	1.00	.90	.40	.50	.50	.90
14	1.40	6.00	2.80	2.30	4.35	1.30	1.00	.80	.40	.50	.50	1.00
15	1.30	4.70	2.80	2.30	6.60	1.30	1.20	.70	.40	.50	.70	1.70
16	1.20	5.75	3.50	2.20	4.90	1.30	.90	.70	.40	.50	.65	2.40
17	1.10	5.90	3.60	2.20	3.90	1.30	.90	.70	.40	.50	.70	2.70
18	1.10	5.30	3.40	2.10	3.50	1.20	.90	.70	.40	.45	.60	2.20
19	1.10	4.90	3.20	2.10	3.20	1.20	.80	.60	.40	.40	.60	1.80
20	1.10	4.60	3.20	2.00	2.90	1.60	1.90	.60	.40	.40	.50	1.60
21	1.10	4.50	3.60	1.90	2.60	1.60	2.60	.60	.40	.45	.60	1.30
22	1.20	6.45	3.40	1.80	2.40	1.40	2.60	.60	.40	.50	.60	1.30
23	1.20	10.05	3.30	1.80	2.30	1.30	1.80	.60	.40	.50	.60	1.30
24	1.20	10.05	3.20	1.70	2.20	1.20	1.50	1.00	.60	.55	.55	1.30
25	1.10	6.70	3.00	1.70	2.20	1.10	1.30	1.30	1.20	.70	.50	1.30
26	1.10	5.50	2.90	1.60	2.20	1.10	1.20	1.00	.50	.80	.50	2.00
27	1.10	4.60	2.70	1.50	1.80	1.10	1.10	.90	.50	.90	.80	1.50
28	1.10	4.60	2.50	1.50	1.60	1.00	1.20	.80	.50	.80	.90	1.60
29	1.10	.....	2.40	1.40	1.60	1.00	1.50	.70	.40	.80	.70	1.50
30	1.10	.....	2.10	1.40	1.60	.90	1.30	.70	.40	.80	.60	1.20
31	1.00	.....	2.00	.....	1.60	.....	1.10	.80	.....	.90	.....	1.10

a Gage washed out.

FREDERICK STATION ON MONOCACY RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 34, is at the county iron bridge on the turnpike 4 miles northeast of Frederick, on the road leading from Frederick to Mount Pleasant, Maryland. A wire gage is attached to the floor timber on the lower side of the bridge. The length of the gage wire from bottom of weight to end of handle is 35.20 feet.

The bench mark is a cross cut in the top face of a capstone on the lower retaining wall of the bridge abutment on the right bank of the stream. It is 24.97 feet above the surface of the water when the gage reads 4.2 feet. The observer is E. L. Derr. The stream at this station has two channels, being divided by a small, low island, which serves as a foundation for the middle pier of the bridge.

On January 26, 1898, the gage was compared with the bench mark, and the wire found to have stretched 0.37 foot. The gage wire was corrected and the gage heights of the preceding months reduced by this amount, those in July and August, when the stretching is supposed to have occurred, being approximated only. The following discharge measurements were made by E. G. Paul and others during the year 1897:

February 9, gage height, 6.00 feet; discharge, 1,019 second-feet.
February 24, gage height, 8.95 feet; discharge, 3,569 second-feet.
March 9, gage height, 6.00 feet; discharge, 1,085 second-feet.
April 10, gage height, 7.55 feet; discharge, 2,264 second-feet.
July 3, gage height, 4.30 feet; discharge, 220 second-feet.
September 3, gage height, 4.15 feet; discharge, 182 second-feet.

Daily gage height, in feet, of Monocacy River at Frederick, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.[a]	Aug.[a]	Sept.	Oct.	Nov.	Dec.
1	4.20	4.40	5.70	5.00	4.60	5.00	4.20	4.90	4.15	3.95	4.15	5.25
2	4.20	4.40	5.50	5.00	6.30	4.80	4.20	4.70	4.05	3.95	14.85	5.15
3	4.20	5.00	5.60	4.90	6.20	4.70	4.30	4.50	4.15	3.85	8.15	5.15
4	4.20	6.00	7.50	4.90	6.20	5.00	4.20	4.40	4.05	3.85	6.55	8.15
5	4.20	5.50	7.50	6.90	6.00	7.50	4.20	4.40	4.05	3.75	5.35	12.40
6	4.30	8.40	8.00	5.90	5.90	5.60	4.20	4.30	3.95	3.85	5.05	8.65
7	4.30	15.00	7.60	5.60	5.60	5.40	4.20	4.30	3.95	3.75	4.85	7.20
8	4.50	8.45	6.20	5.40	5.40	4.95	4.20	4.20	3.95	3.75	4.75	6.55
9	4.40	6.00	6.00	9.30	5.10	6.15	4.90	4.20	3.95	3.75	5.55	5.95
10	4.30	5.60	6.50	8.55	5.00	5.80	4.50	4.20	3.95	3.85	5.55	5.75
11	4.20	5.20	6.20	6.55	5.10	5.30	4.20	10.60	3.95	3.85	4.85	5.55
12	4.30	5.20	5.80	6.60	5.10	5.00	4.20	8.50	3.95	3.85	4.75	6.85
13	4.30	4.90	5.80	5.70	15.60	4.90	7.00	5.45	3.95	4.25	4.65	6.65
14	4.30	4.60	5.70	5.80	15.60	4.70	5.20	4.45	3.85	4.15	4.55	11.65
15	4.00	4.60	5.70	5.90	10.90	4.70	4.60	4.25	3.85	4.05	5.15	14.95
16	4.00	5.70	5.80	6.20	7.40	4.70	4.30	5.35	3.85	3.95	5.55	13.85
17	4.00	7.40	5.40	5.80	6.80	4.80	4.30	4.85	4.45	3.95	4.95	7.15
18	4.00	7.40	6.60	5.80	6.50	4.80	5.10	4.30	4.45	3.85	4.75	6.65
19	4.30	6.70	7.00	5.50	6.10	4.70	4.95	4.10	4.05	3.75	4.65	6.15
20	4.70	6.10	9.80	5.80	5.80	4.70	5.25	4.10	3.85	3.75	4.55	5.95
21	4.50	5.70	7.80	5.10	5.90	4.90	4.95	4.10	3.85	3.85	4.65	5.85
22	5.50	12.13	6.60	5.00	6.00	4.70	6.40	5.50	3.95	3.95	4.55	6.55
23	5.40	14.60	6.50	5.00	5.50	4.50	5.65	4.80	3.95	3.95	4.75	6.05
24	4.80	8.85	7.40	5.00	5.30	4.50	4.95	16.20	5.65	3.95	5.60	5.65
25	5.20	8.30	7.30	4.90	6.70	4.40	4.45	6.75	5.15	4.05	4.85	5.15
26	5.00	7.00	6.10	4.90	6.00	4.40	4.35	5.75	4.65	4.35	6.55	5.55
27	5.00	6.50	5.80	4.90	5.30	4.40	7.70	5.10	3.95	4.25	7.05	5.45
28	5.00	6.00	5.60	4.80	5.20	4.40	9.90	4.70	3.95	4.15	6.55	5.45
29	5.00	.....	5.40	4.70	5.00	4.20	7.80	4.25	3.95	4.05	5.85	5.35
30	4.80	.....	5.30	4.60	4.90	4.20	6.10	4.15	3.95	4.05	5.65	5.35
31	4.50	.....	5.20	.....	5.00	.....	5.30	4.15	.....	3.95	.....	5.45

[a] Approximate.

POINT OF ROCKS STATION ON POTOMAC RIVER.

This station, described in the Eighteenth Annual Report of this Survey, Part IV, page 29, is about 6 miles above the mouth of Monocacy River, at Point of Rocks, Maryland. At this point a toll bridge crosses the stream 1,000 feet below the mouth of Catoctin Creek. A wire gage has been established on the east side of the first span; the scale is marked with nails on the hand rail. Bench mark 1 is a copper bolt fastened in a hole drilled in a large capstone on the lower wing wall of the north abutment, a short distance from the north end of the first iron truss, and is 41.30 feet above the datum of the gage. Bench mark 2, top of second floor beam from left bank, lower end, is 39.28 feet above datum. The distance from the end of the weight to the wire index is 44.22 feet. On January 25, 1898, a comparison with the bench mark revealed that the gage wire had stretched 1.78 feet. A new wire was substituted and the gage heights of the preceding months were reduced to the correct datum; those in August and September, when the stretching is supposed to have occurred, being approximated only. The observer is G. H. Hickman. During the year 1897 discharge measurements were made by E. G. Paul and G. H. Matthes, as follows:

February 9, gage height, 7.95 feet: discharge, 40,654 second-feet.
February 23, gage height, 21.70 feet; discharge, 169,913 second-feet.
March 8, gage height, 5.70 feet; discharge, 27,383 second-feet.
March 27, gage height, 4.05 feet; discharge, 17,121 second-feet.
July 23, gage height, 2.85 feet; discharge, 8,130 second-feet.
October 29, gage height, 0.20 foot; discharge, 2,141 second-feet.

Daily gage height, in feet, of Potomac River at Point of Rocks, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.[a]	Sept.[a]	Oct.	Nov.	Dec.
1	0.80	2.00	5.30	2.80	2.20	2.50	1.80	1.80	0.30	0.00	0.20	0.90
2	.80	1.90	4.40	2.70	2.40	2.40	1.70	1.70	.20	.00	.30	.90
3	.80	2.50	4.20	2.60	7.00	2.30	1.80	1.50	.20	.00	1.00	.90
4	.90	2.00	4.10	2.60	14.50	2.40	1.80	1.40	.20	.00	1 40	1.00
5	.90	2.10	4.60	2.70	9.00	2.50	1.70	1.30	.20	.00	1.00	1.10
6	1.00	5.10	4.40	3.00	6.50	2.50	1.70	1.70	.20	— .10	.80	3.20
7	1.40	8.00	6.00	3.30	5.90	2.40	1.70	1.20	.20	— .10	.70	3.60
8	1.70	10.50	5.80	3.50	5.10	2.50	1.70	1.10	.10	— .10	.50	3.20
9	1.50	7.90	5.00	3.40	4.50	2.50	1.60	1.10	.00	— .10	.50	2.40
10	1.30	5.80	4.50	4.20	4.00	2.30	1.50	1.10	.00	— .10	.50	1.50
11	1.10	4.60	4.20	6.20	3.70	2.20	1.90	1.10	— .10	.00	.70	1.30
12	1.10	4.00	4.00	5.10	3.50	2.20	1.80	1.00	— .10	.10	1.20	1.10
13	1.10	3.90	3.90	4.40	3.80	2.10	1.80	1.00	— .10	— .10	.80	1.00
14	.90	4.60	3.70	4.00	9.40	2.10	1.90	.80	— .10	.00	.50	.90
15	.90	5.70	3.70	3.80	13.10	2.20	1.90	.80	— .10	.00	.50	1.50
16	1.00	7.00	3.80	3.60	8.50	2.20	2.00	.80	— .10	— .10	.60	4.10
17	.90	7.40	4.20	3.50	5.50	2.10	1.80	.60	— .10	— .10	1.10	4.30
18	.90	7.70	4.40	3.40	4.90	2.10	1.60	.50	— .10	— .10	.90	3.30
19	.90	7.60	4.70	3.30	4.60	2.20	1.90	.40	— .10	— .10	.70	2.60
20	1.50	7.20	5.30	3.10	4.40	2.20	1.90	.30	— .10	— .10	.70	2.20
21	1.50	6.40	6.20	3.00	4.00	2.60	2.60	.30	— .10	— .10	.60	2.10
22	1.40	6.70	6.00	2.80	3.70	2.50	3.10	.30	— .10	.00	.60	1.60
23	1.40	21.15	5.55	2.70	3.40	2.30	3.20	.30	.00	— .10	.60	1.50
24	1.40	24.60	4.80	2.60	3.30	2.20	2.60	.30	.20	— .10	.40	1.40
25	1.50	16.10	4.70	2.60	3.40	2.10	2.40	.90	.00	.00	.40	1.30
26	1.80	9.30	4.60	2.50	3.50	2.10	2.40	.80	.00	.00	.40	1.30
27	2.00	7.30	4.10	2.40	3.30	2.10	2.60	.40	.00	.00	1.00	1.20
28	2.30	6.00	3.80	2.40	3.00	2.00	2.70	.40	.00	.10	.60	1.20
29	2.20	.....	3.60	2.30	2.70	1.90	2.60	.40	.00	.20	.50	1.10
30	2.10	.....	3.30	2.20	2.60	1.80	2.40	.40	.00	.20	.60	1.10
31	2.00	.....	2.90	.....	2.50	.....	2.30	.40	.....	.20	.....	1.10

[a] Approximate.

PARK STATION ON ROCK CREEK.

A station was established on Rock Creek January 18, 1897, at the Park bridge, near the eastern entrance of the National Zoological Park, in the city of Washington, District of Columbia. The upper part of the gage is vertical and is fastened to the bridge abutment, the lower portion being inclined and fastened to iron rods. The bench mark consists of an X on the stone of the bridge pier. It is 9.13 feet above the zero of the gage. The observer is W. V. Kramer, one of the watchmen in the park. A measurement on August 18, 1897, at a gage height of 2.90 feet gave a discharge of 26 second-feet, and on November 21, at a gage height of 3.00 feet a discharge of 37 second-feet.

A study of the discharge of Rock Creek was begun in July, 1892, at the request of the Commissioners of the District of Columbia. In July, 1892, a gage rod was established by Cyrus C. Babb at Lyon's Mill, and fastened to the downstream face of the right abutment of the bridge. On August 18, 1892, a self-registering gage was placed at the bridge, and the record continued until November 30, 1894.

The following are the discharge measurements made at this point:

July 28, 1892, gage height, 0.00 foot; discharge, 89 second-feet.
August 2, 1892, gage height, —0.30 foot; discharge, 49 second-feet.
August 3, 1892, gage height, —0.3 foot; discharge, 48 second-feet.
August 5, 1892, gage height, 0.19 foot; discharge, 102 second-feet.
April 11, 1893, gage height, —0.12 foot; discharge, 58 second-feet.
May 4, 1893, gage height, 4.14 feet; discharge, 959 second-feet.

Daily gage height, in feet, of Rock Creek at Zoological Park Bridge, District of Columbia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.90	2.35	2.30	2.30	2.30	3.10	3.05	2.85	2.80	3.10	3.05
2	.....	3.50	2.35	2.25	2.40	2.50	3.10	3.00	2.85	2.85	3.50	3.05
3	.....	4.15	2.35	2.25	2.45	2.65	3.10	3.00	2.85	2.85	3.30	3.05
4	.....	3.45	2.40	2.25	2.55	2.95	3.05	2.95	2.85	2.85	3.10	3.25
5	.....	3.15	2.35	2.50	2.50	3.15	3.05	2.95	2.85	2.85	3.05	3.90
6	.....	3.25	2.35	2.65	2.35	3.10	3.05	3.00	2.85	2.85	3.00	3.35
7	.....	4.25	2.40	2.45	2.30	3.25	3.05	2.95	2.80	2.85	2.95	3.20
8	.....	2.70	2.35	2.40	2.20	3.40	3.60	2.95	2.80	2.85	3.00	3.15
9	.....	2.50	2.35	3.15	2.20	3.45	3.15	2.95	2.80	2.85	3.20	3.10
10	.....	2.40	2.35	2.90	2.15	3.40	3.10	2.95	2.80	2.85	3.35	3.10
11	.....	2.30	2.30	2.60	2.20	3.40	3.10	3.00	2.80	2.85	3.10	3.10
12	.....	2.45	2.30	2.50	2.50	3.35	3.25	3.00	2.80	3.15	3.05	3.10
13	.....	2.60	2.35	2.45	3.70	3.35	3.30	2.95	2.80	2.85	3.05	3.10
14	.....	2.60	2.45	2.45	2.65	3.35	3.30	2.90	2.80	2.85	3.00	3.25
15	.....	2.65	2.60	2.40	2.95	3.35	3.10	2.90	2.80	2.85	3.05	4.30
16	.....	2.45	2.40	2.45	2.60	3.35	3.00	2.95	2.80	2.85	3.10	3.35
17	.....	2.40	2.35	2.45	2.50	3.35	3.10	3.00	2.80	2.85	3.05	3.20
18	3.00	2.30	2.95	2.40	2.40	3.35	3.10	2.90	2.90	2.90	3.05	3.15
19	2.95	2.30	2.85	2.35	2.40	3.20	3.45	2.90	2.85	2.90	3.05	3.10
20	2.90	2.25	3.05	2.30	2.35	3.30	3.25	2.90	2.80	3.00	3.05	3.10
21	3.15	2.40	2.90	2.30	2.30	3.25	3.25	2.90	2.80	3.00	3.00	3.15
22	3.30	3.75	2.65	2.30	2.30	3.15	4.00	2.90	2.80	2.95	3.00	3.20
23	3.35	4.10	2.55	2.30	2.25	3.15	3.40	2.90	2.90	2.95	3.05	3.20
24	3.05	2.85	2.60	2.30	2.60	3.15	3.10	2.95	3.20	3.00	3.05	3.30
25	2.90	2.60	2.55	2.30	3.45	3.25	3.05	2.90	2.90	3.10	3.00	3.05
26	3.00	2.50	2.40	2.25	2.55	3.15	3.00	2.90	2.80	3.10	3.05	3.10
27	2.90	2.45	2.40	2.25	2.40	3.10	3.45	2.90	2.80	3.00	3.95	3.10
28	2.90	2.45	2.35	2.20	2.35	3.10	4.30	2.85	2.80	2.95	3.30	3.05
29	2.95	.....	2.30	2.25	2.30	3.10	3.10	2.85	2.80	2.90	3.15	3.00
30	2.90	.....	2.30	2.25	2.30	3.10	3.10	2.85	2.80	2.90	3.10	3.10
31	2.90	.....	2.30	.....	2.25	.....	3.10	2.85	.....	2.90	.....	3.10

GLASGOW STATION ON NORTH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 36, is at the Glasgow, Virginia, county bridge about 1 mile above the mouth of North River. The height of water is observed by means of a wire gage, the board being placed on the guard rail on the lower side of the bridge and graduated in feet and tenths. The distance from the top of the bridge over the gage to the zero is 32.24 feet, and that from the end of the weight to the marker of the gage is 27.86 feet. The observer is B. G. Baldwin. Discharge measurements are made at the bridge. The initial point for sounding is on the left bank. The channel is straight for about 200 feet above and below the station, but farther downstream it is curved, and the water moves with moderate velocity. The stream is confined within its channel by the bridge abutments, except at very high water, when it may overflow the left bank. The bed is composed of rock and gravel and is fairly permanent. The following discharge measurements were made by Prof. D. C. Humphreys and F. H. Anschutz during 1897:

May 29, gage height, 1.91 feet; discharge, 546 second-feet.
August 14, gage height, 1.17 feet; discharge, 208 second-feet.
October 14, gage height, 1.30 feet; discharge, 223 second-feet.

Daily gage height, in feet, of North River at Glasgow, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.52	1.70	2.85	2.22	1.78	1.85	1.35	.....	1.17	1.08	1.40	1.40
2	1.51	1.74	2.68	2.21	5.80	1.78	2.65	1.20	1.14	1.05	1.65	1.42
3	.....	1.76	2.58	2.22	4.70	1.75	1.95	1.20	1.10	1.05	1.60	1.38
4	1.55	1.80	2.50	2.27	3.52	1.75	1.88	1.14	1.10	1.02	1.50	1.41
5	1.60	1.92	2.46	2.38	3.05	1.85	1.80	1.52	1.08	1.02	1.41	1.60
6	1.75	4.70	2.40	2.58	2.76	.....	1.73	1.32	1.05	1.03	1.30	1.80
7	1.65	6.05	2.40	2.55	2.58	1.87	1.66	1.25	1.08	1.03	1.20	1.75
8	1.60	4.86	2.42	2.50	2.40	1.85	1.60	1.18	1.07	1.02	1.41	1.68
9	1.65	4.50	2.40	2.52	.....	1.80	1.52	1.18	1.05	1.02	1.25	1.60
10	1.65	3.62	2.48	2.62	2.20	1.75	1.45	1.15	1.00	1.00	1.23	1.52
11	1.60	3.51	2.48	.....	2.20	1.70	1.38	1.18	1.00	1.10	1.20	1.50
12	1.60	3.32	2.58	2.52	2.22	1.63	1.30	1.15	.....	1.20	1.18	1.45
13	1.58	4.40	3.00	2.38	4.70	.....	1.25	1.12	1.05	1.18	1.18	1.45
14	1.58	4.05	.....	2.30	7.30	1.65	1.20	1.17	1.10	1.15	1.18	1.56
15	1.55	3.81	4.26	2.27	4.42	1.72	1.20	.....	1.08	1.20	1.20	2.62
16	1.52	4.00	3.70	2.25	.....	1.66	1.18	1.20	1.10	1.18	1.18	2.65
17	1.53	3.90	3.27	2.14	3.20	1.67	1.12	1.20	1.08	1.20	1.20	2.15
18	1.55	3.50	3.33	2.08	2.93	1.66	1.40	1.16	1.10	1.18	1.15	2.00
19	1.55	3.40	.....	2.00	2.77	1.65	1.30	1.10	1.10	1.20	1.21	1.85
20	1.52	3.40	3.72	2.00	2.56	.....	1.30	1.10	1.05	1.20	1.15	1.70
21	1.70	.....	3.46	1.90	2.50	1.90	1.35	1.08	1.08	1.20	1.16	1.65
22	1.90	5.10	3.20	1.88	2.35	1.70	1.70	.....	1.10	1.25	1.15	1.80
23	2.02	7.72	3.00	1.88	.....	1.62	(a)	1.14	1.10	1.20	1.15	1.75
24	1.98	5.35	3.00	1.87	2.23	1.60	(a)	1.40	1.12	1.18	1.20	1.70
25	1.90	4.75	2.90	1.86	2.20	1.60	(a)	1.30	1.11	1.20	1.12	1.68
26	1.85	3.36	2.70	1.86	2.10	1.50	1.25	1.30	1.10	1.20	1.15	1.75
27	1.75	3.15	2.60	1.80	2.02	1.45	1.25	1.42	1.10	1.18	1.20	1.80
28	1.70	2.95	2.54	1.75	2.00	1.40	1.26	1.27	1.09	1.22	1.20	1.80
29	1.60	.....	2.42	1.75	1.95	1.40	1.23	.....	1.10	1.15	1.40	1.75
30	1.60	.....	2.31	1.75	.....	1.38	1.23	1.20	1.10	1.25	1.42	1.68
31	1.65	.....	2.30	.....	1.90	.....	1.24	1.18	.....	1.28	.....	1.60

a Gage broken.

July 4–14 interpolated by D. C. Humphreys.

BUCHANAN STATION ON JAMES RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 39, is on James River, about 20 miles above the mouth of North River and one-half mile above the mouth of Purgatory Creek, at the new iron bridge at Buchanan, Virginia. The gage is of wire, and the scale is painted in feet and tenths. The bench mark at this point is the top of a stone post under the southwest corner of the porch of the Chesapeake and Ohio passenger station; the elevation of the bench mark is 24.68 feet above the zero of the gage. The highest point on a prominent ledge of rock on the left bank, about 500 feet above the bridge, is 17.48 feet above the zero of the gage. On April 3, 1897, the zero of this gage was lowered 2 feet to avoid negative readings. The published gage readings for 1897 are referred to this new gage. A new iron bridge was erected at this point in November, and future discharge measurements will be made at this bridge, on which the gage is located. Discharge measurements were made at a bridge three-fourths of a mile above, as the old covered bridge was not suited to the purpose. The initial point was taken on the right bank; the channel is nearly straight both above and below, and the bed of the stream is mostly solid rock and is subject to but little change. The following measurements were made by D. C. Humphreys and others during 1897:

April 1, gage height, 3.30 feet; discharge, 2,007 second-feet.
May 30, gage height, 2.70 feet; discharge, 994 second-feet.
October 13, gage height, 1.70 feet; discharge, 578 second-feet.

Daily gage height, in feet, of James River at Buchanan, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.70	4.25	3.30	2.60	2.50	2.10	2.20	1.80	1.30	1.60	1.70
2	2.10	2.80	4.10	3.30	6.40	2.50	2.20	2.10	1.80	1.30	1.80	1.80
3	2.10	2.90	3.85	3.00	7.75	2.50	3.05	2.00	1.70	1.30	1.80	1.90
4	2.10	2.90	3.70	3.00	5.85	3.00	2.70	2.00	1.70	1.30	1.80	2.10
5	2.10	2.90	3.60	3.15	5.20	2.65	2.45	2.40	1.70	1.30	1.70	2.20
6	2.10	8.00	3.50	4.15	5.15	2.50	2.30	2.10	1.70	1.30	1.70	2.20
7	2.10	12.15	3.50	4.00	4.85	2.50	2.30	2.00	1.70	1.30	1.60	2.20
8	2.10	8.80	3.75	3.75	4.60	2.50	2.50	2.00	1.60	1.30	1.60	2.20
9	2.10	7.25	3.70	3.60	4.15	2.50	2.45	2.00	1.60	1.30	1.60	2.20
10	2.10	6.75	3.70	4.10	3.95	2.40	2.30	1.90	1.60	1.30	1.60	2.20
11	2.10	6.10	4.45	4.20	3.85	2.40	2.20	1.90	1.60	1.30	1.60	2.20
12	2.10	5.80	4.90	3.95	3.85	2.35	2.20	1.90	1.60	1.75	1.50	2.20
13	2.10	8.15	6.25	3.70	6.15	2.30	2.20	1.90	1.60	1.75	1.50	2.20
14	2.10	6.50	5.85	3.60	10.45	2.30	2.20	1.90	1.60	1.70	1.40	2.20
15	2.10	6.20	7.90	3.60	7.30	2.40	2.20	1.90	1.60	1.70	1.35	2.55
16	2.10	6.25	6.45	3.50	5.90	2.40	2.20	1.80	1.60	1.70	1.30	2.85
17	2.10	6.50	5.60	3.35	5.00	2.40	2.20	1.80	1.50	1.70	1.30	2.90
18	2.10	5.55	5.10	3.20	4.55	2.40	2.10	1.80	1.50	1.60	1.30	2.70
19	2.10	5.30	6.00	3.10	4.10	2.40	2.20	1.80	1.50	1.60	1.30	2.70
20	2.10	5.30	6.75	3.00	3.80	3.10	2.20	1.80	1.50	1.50	1.30	2.70
21	2.30	6.05	6.35	3.00	3.55	2.50	2.30	1.80	1.50	1.50	1.30	2.70
22	2.30	11.50	5.65	2.90	3.35	2.50	3.35	1.80	1.50	1.50	1.30	2.70
23	2.30	14.00	5.00	2.80	3.15	2.50	3.30	1.80	1.55	1.70	1.30	2.60
24	2.70	11.65	4.65	2.80	3.15	2.40	3.05	2.25	1.90	1.70	1.30	2.85
25	2.90	7.50	4.45	2.70	3.20	2.30	3.05	2.10	1.60	1.70	1.30	2.90
26	2.80	6.10	4.15	2.70	3.10	2.20	2.75	2.00	1.50	1.70	1.30	2.90
27	2.60	5.35	3.95	2.70	3.00	2.40	2.55	2.00	1.50	1.70	1.30	2.90
28	2.90	4.75	3.80	2.60	2.90	2.30	2.50	1.90	1.50	1.60	1.30	2.85
29	2.90	.....	3.65	2.60	2.75	2.20	2.45	1.90	1.40	1.60	1.40	2.70
30	2.90	.....	3.50	2.60	2.70	2.10	2.40	1.90	1.40	1.60	1.50	2.60
31	2.70	.....	3.40	.....	2.55	.....	2.30	1.80	.....	1.60	.....	2.60

ROANOKE STATION ON ROANOKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 42, is located in the edge of the town of Roanoke, Virginia., at the Walnut-street bridge. The gage is of wire, and the scale is painted in feet and tenths on a horizontal rod fastened to the floor of the bridge. The distance from the end of weight to marker is 24.39 feet. The top of lower end of first floor beam is 21.99 feet above datum of gage. The right bank is above high water, but the left may overflow at extreme high water. The channel is nearly straight and the current good. The observer is A. B. Rawn. A discharge measurement was made on April 2, 1897, by F. H. Anschutz, when the water stood at a height of 1.52 feet, giving a discharge of 320 second-feet.

Daily gage height, in feet, of Roanoke River at Roanoke, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.75	0.45	1.75	1.55	1.55	1.30	0.70	0.75	0.75	1.50	0.85	0.50
2	.70	.45	1.55	1.55	4.00	1.30	.70	.75	.70	1.45	.85	.50
3	.70	.45	1.20	1.50	3.85	1.75	.75	.80	.65	1.40	.80	.50
4	.65	.45	1.00	1.85	3.45	1.70	.72	.80	.65	1.30	.80	.90
5	.63	.50	.95	1.80	2.95	1.65	.72	1.75	.65	1.25	.80	1.30
6	.60	6.82	.90	1.75	2.75	1.60	.72	1.70	.65	1.20	.75	1.15
7	.55	3.78	1.85	1.70	2.60	1.55	.72	1.65	.65	1.10	.75	1.10
8	.50	2.60	1.25	1.65	2.50	1.55	.70	1.40	.60	1.00	.75	1.00
9	.45	2.20	1.00	1.60	2.25	1.50	.70	1.20	.60	.90	.75	.95
10	.45	1.95	.95	1.55	1.90	1.50	.65	1.00	.60	.90	.70	.95
11	.45	1.90	.90	1.50	1.60	1.50	.62	.80	.55	.85	.70	.90
12	.45	3.00	1.95	1.50	1.58	1.45	1.00	.75	.45	.85	.65	.85
13	.45	2.90	2.20	1.50	1.55	1.45	1.00	.75	.45	1.90	.60	.85
14	.45	2.50	3.60	1.50	1.55	1.40	.95	.75	.45	1.95	.60	.80
15	.50	2.20	3.85	1.50	1.75	1.45	.90	.70	.40	1.85	.60	.80
16	.60	2.00	3.30	1.60	1.70	1.40	.85	.70	.40	1.70	.60	.80
17	.65	1.95	3.00	1.55	1.65	1.40	1.00	.70	.40	1.45	.60	.80
18	.60	1.80	3.00	1.50	1.60	1.35	1.10	.70	.35	1.20	.60	.80
19	.60	1.55	2.90	1.45	1.55	1.75	1.00	.70	.35	1.00	.60	.85
20	.65	1.45	2.75	1.45	1.55	1.75	1.10	.65	.35	1.20	.55	.85
21	.68	4.50	2.60	1.40	1.55	1.70	1.55	.65	.35	1.10	.55	.90
22	.70	4.40	2.45	1.40	1.50	1.65	1.45	.65	.35	1.00	.55	.90
23	.70	8.30	2.10	1.40	1.50	1.60	1.95	.90	1.85	.90	.55	.90
24	.65	3.50	1.95	1.40	1.50	1.55	1.85	1.10	1.85	.90	.55	.95
25	.65	2.60	1.75	1.40	1.45	1.50	1.70	.....	1.75	.85	.50	.95
26	.60	2.20	1.45	1.35	1.45	1.40	1.55	.....	1.70	1.10	.50	.95
27	.50	1.90	1.25	1.30	1.40	1.00	1.40	.....	1.65	1.10	.50	.95
28	.50	1.85	1.65	1.30	1.40	.72	1.25	.....	1.60	1.00	.50	1.00
29	.50	.....	1.63	1.25	1.40	.72	1.00	.75	1.55	.95	.50	1.00
30	.50	.....	1.60	1.20	1.35	.72	.80	.75	1.55	.90	.50	1.10
31	.45	.....	1.58	.....	1.35	.....	.75	.80	.....	.85	.....	1.10

CLARKSVILLE STATION ON DAN AND STAUNTON RIVERS.

This station, described in the Eighteenth Annual Report, Part IV, page 42, is a short distance above the junction of the Dan and Staunton rivers, which unite to form the Roanoke River. On Dan River the rod is fastened to the inside of the guard rail of the fourth panel of the third span west of the Southern Railroad bridge. The distance from the zero of the rod to the outside of the pulley wheel is 3 feet; the length of the wire rope is 33.17 feet. The water power from Dan River has been developed to a considerable extent at Danville. An examination at points above showed that the dams at Danville pond the water, and as a result modify the natural characteristics of the stream. The gage on Staunton River is fastened to the inside of the guard rail of the fourth panel of the third span from the west. The distance from the zero to the outside of the pulley wheel is 3 feet; the length of the wire gage is 33.0 feet; the distance of the water surface below the top and upper end of the third-floor beam of the second span from the west was 27.15 feet when the gage height was 0.25 foot. The distance from the east abutment of the Dan River bridge to the west abutment of the Staunton River bridge is 165 feet. The observer is Lucius Wootton. About 4 miles above the junction of the Dan and Staunton rivers is a cut-off, apparently occupying an old channel, diverting water from the Dan to the Staunton. This cut-off, by carrying water from the Dan, vitiates the separate computations of discharge made at the stations below, but does not affect the total discharge for the Roanoke. The following measurements were made during 1897 by E. W. Myers:

On Dan River:
February 25, gage height, 12.33 feet; discharge, 26,015 second-feet.
March 18, gage height, 4.20 feet; discharge, 7,755 second-feet.
September 29, gage height, 0.10 foot; discharge, 856 second-feet.
On Staunton River:
February 25, gage height, 11.95 feet; discharge, 29,259 second-feet.
March 18, gage height, 3.67 feet; discharge, 8,326 second-feet.
September 29, gage height, —0.25 foot; discharge, 763 second-feet.

Daily gage height, in feet, of Dan River at Clarksville, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.75	2.70	2.90	1.98	1.72	1.60	1.10	0.71	0.23	0.05	1.55	2.75
2	1.75	3.20	2.75	1.95	2.85	1.56	1.03	.67	.20	.05	1.92	2.35
3	1.74	4.05	2.67	2.00	5.30	1.55	.98	.55	.15	.02	2.45	2.05
4	1.74	2.70	2.35	2.15	4.80	1.63	.95	.48	.15	.01	2.05	1.90
5	1.75	1.85	3.55	2.35	3.25	1.70	.90	.42	.00	— .03	1 60	1.85
6	1.77	2.35	4.65	2.85	3.10	1.08	.87	.38	.00	— .05	1.20	1.65
7	1.75	6.35	4.75	3.15	3.70	1.00	.83	.35	.00	— .09	.98	1.40
8	1.71	12.29	4.60	3.45	3.45	1.04	.98	.35	.00	— .15	.85	1.18
9	1.68	9.20	4.47	3.25	3.05	1.04	.90	.37	.00	— .02	.68	1.05
10	1.65	4.75	3.98	4.10	2.75	1.03	.85	.73	.00	+ .05	.55	.85
11	1.62	3.15	4.03	3.72	3.25	1.02	.80	.79	.00	.05	.42	.70
12	1.60	2.70	4.78	3.45	3.95	1.00	.70	.68	.00	1.10	.35	.65
13	1.58	3.95	4.90	3.15	4.25	.98	1.75	.65	.00	1.95	.25	.60
14	1.65	3.35	5.70	2.95	4.98	.98	1.30	.48	.00	1.25	.25	.65
15	1.68	3.15	4.95	2.70	5.30	.96	1.18	.42	.00	1.10	.18	.85
16	1.65	3.70	4.10	2.45	4.65	.95	.90	.48	.00	.95	.14	.95
17	1.68	4.05	3.45	2.17	4.15	.94	.75	.55	.00	1.65	.10	1.25
18	2.50	3.25	4.30	2.05	3.75	.92	.88	.75	.00	2.10	.05	1.55
19	3.45	2.85	3.95	1.98	3.15	.90	1.98	.85	.00	2.48	.25	1.40
20	4.05	3.35	3.62	1.90	2.85	.95	1.85	.95	.00	3.00	.23	1.10
21	3.50	4.10	3.40	1.86	2.25	.90	2.25	1.08	.00	1.55	.23	1.70
22	2.65	6.70	3.22	1.78	1.90	.88	1.48	.70	.00	.75	.22	2.35
23	2.05	8.45	3.03	1.75	1.88	.90	1.25	.80	.00	1.10	.20	4.10
24	1.85	11.52	2.70	1.75	1.85	.95	1.17	.75	.00	.88	.18	3.45
25	1.75	12.80	2.55	1.72	1.83	.93	.98	.58	.05	.65	.30	2.65
26	1.55	4.64	2.35	1.68	1.79	.90	.79	.42	.25	.85	.35	2.18
27	1.25	3.25	2.28	1.63	1.77	.88	.70	.35	.40	1.15	.58	1.80
28	.85	3.05	2.25	1.60	1.73	.95	.68	.30	.25	2.25	2.10	1.45
29	1.15	.....	2.15	1.57	1.66	.88	1.15	.28	.10	2.85	5.40	1.20
30	1.25	.....	2.08	1.55	1.63	.80	1.08	.28	.08	2.10	3.85	1.10
31	2.10	.....	2.03	.....	1.60	.....	.77	.25	.....	1.85	.....	.95

Daily gage height, in feet, of Staunton River at Clarksville, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.75	3.60	2.25	1.60	1.15	1.00	.....	0.35	0.30	—0.31	1.00	2.20
2	2.75	4.10	2.12	1.55	2.48	.98	.....	.31	.20	— .31	1.50	1.85
3	2.74	4.92	2.05	1.60	4.72	.96	.....	.28	.00	— .35	2.12	1.63
4	2.74	3.55	1.93	1.70	4.30	1.03	0.65	.20	.00	— .40	1.55	1.47
5	2.75	2.68	2.85	1.92	2.70	1.11	.60	.14	.00	— .45	.95	1.30
6	2.77	3.23	4.02	2.52	2.52	1.09	.57	.10	.00	— .48	.78	1.18
7	2.75	6.05	4.20	2.75	3.10	1.06	.54	.08	.00	— .52	.59	1.02
8	2.71	11.85	4.05	2.95	2.98	1.05	.51	.08	.00	— .58	.43	.84
9	2.68	8.85	3.85	2.72	2.60	1.05	.66	.09	.00	— .65	.25	.70
10	2.65	4 25	3.35	3.55	2.28	1.02	.59	.40	.00	— .40	.12	.52
11	2.62	2.58	3.45	3.15	2.85	1.98	.48	.46	.00	+ .40	.05	.40
12	2.60	2.20	4.20	2.85	3.45	1.96	.34	.31	.00	.60	.02	.37
13	2.58	3.50	4.35	2.53	3.73	.....	1.15	.29	.00	1.55	— .05	.35
14	2.65	2.85	5.15	2.30	4.43	.....	.80	.20	.00	.66	— .10	.37
15	2.68	2.55	4.37	2.05	4.72	.....	.61	.14	.00	.60	— .20	.52
16	2.65	3.15	3.60	1.75	4.10	.....	.50	.20	.00	.53	— .24	.57
17	2.68	3.70	2.97	1.46	3.65	.....	.40	.28	.00	1.05	— .30	.65
18	3.51	2.90	3.78	1.45	3.28	.....	.48	.40	.00	1.33	— .38	1.00
19	4.47	2.35	3.40	1.38	2.75	.....	1.43	.59	.00	1.79	— .10	1.02
20	5.07	2.85	3.15	1.33	2.58	.....	1.35	.65	.00	2.30	— .13	.72
21	4.52	2.90	2.90	1.28	1.70	.....	1.65	.71	.00	1.00	— .13	1.25
22	3.66	6.07	2.77	1.20	1 57	.....	1.15	.34	.60	.25	— .14	1.85
23	3.06	7.75	2.50	1.15	1.33	.....	.87	.48	.00	.60	— .16	4.50
24	2.85	10.70	2.30	1.15	1.29	.....	.84	.40	.00	.30	— .20	2.88
25	1.74	12.04	2.05	1.15	1.26	.....	.51	.30	.00	.07	— .05	2.08
26	1.54	3.05	1.98	1.12	1.21	.....	.46	.16	.00	.28	— .02	1.68
27	1.24	2.65	1.83	1.08	1.18	.....	.34	.09	.05	.62	+ .17	1.35
28	.83	2.35	1.80	1.05	1.13	.....	.32	.07	.00	1.85	1.33	1.05
29	1.14	.....	1.72	1 01	1 05	.....	.78	.30	—.25	2.40	4.70	.80
30	1.24	.....	1.68	.95	1.02	.....	.58	.80	—.28	1.33	2.77	.70
31	2.85	.....	1.65	.....	1.00	.....	.45	.50	.....	1.30	.....	.57

June 13 to July 3 no reports; repairing bridge.

NEAL STATION ON ROANOKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 47, is on the Norfolk and Carolina Railroad bridge near Neal, North Carolina. The zero of the gage rod is over the center of the fourth floor beam of the second span from the north end of the bridge. The distance from the zero of the rod to the outer rim of the pulley is 2.47 feet, and the distance from the end of the weight to the pointer on the wire is 44.66 feet. The section is a fairly good one, for the course of the river is straight for some distance above and below the station, and the bottom is smooth. Being muddy, however, the bottom is apt to cut out in seasons of high water, and both banks are liable to overflow. The observer is W. M. Adams, Neal, North Carolina. The following measurements were made during 1897 by E. W. Myers:

January 23, gage height, 12.65 feet; discharge, 13,155 second-feet.
February 27, gage height, 27.95 feet; discharge, 64,132 second-feet.
March 17, gage height 24.71 feet; discharge, 37,659 second-feet.
May 17, gage height, 18.40 feet; discharge, 19,219 second-feet.
October 1, gage height, 1.00 feet; discharge, 1,928 second-feet.

Daily gage height, in feet, of Roanoke River at Neal, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.40	3.40	24.20	9.30	6.40	5.90	3.90	3.90	2.20	1.20	3.10	11.00
2	4.70	4.30	23.70	9.00	6.40	5.50	3.40	3.20	2.10	.80	3.40	10.10
3	5.00	11.50	19.10	8.70	6.80	5.90	3.10	2.60	2.90	.60	4.20	8.70
4	4.90	20.25	16.90	8.50	12.60	5.90	6.80	2.10	3.90	.50	5.50	7.30
5	4.90	21.50	14.90	8.40	17.10	5.30	6.90	2.00	3.40	.40	8.10	6.30
6	4.60	20.90	13.60	9.40	14.90	4.90	5.30	2.10	2.60	.30	7.50	6.90
7	4.40	21.10	15.20	11.00	12.40	5.70	3.90	1.90	2.00	.30	5.80	7.70
8	4.40	22.80	21.05	14.10	10.60	7.40	3.30	1.90	1.50	.20	4.50	7.80
9	4.50	24.30	22.25	13.40	9.10	7.50	3.30	2.40	1.10	.10	3.60	7.20
10	4.50	26.30	22.70	14.10	8.10	6.20	5.00	3.10	.90	.10	3.00	6.50
11	4.20	26.55	22.20	19.90	7.40	5.60	5.20	3.00	.80	.10	2.67	5.70
12	3.90	24.65	21.60	19.60	6.90	6.00	4.80	3.20	.60	.20	2.50	4.80
13	3.80	22.70	22.30	17.00	7.00	5.60	5.40	4.30	.50	.20	2.40	4.48
14	4.00	21.20	23.40	14.40	8.90	5.30	5.80	3.30	.50	.30	2.20	4.10
15	4.20	20.60	23.90	12.50	17.30	4.70	6.20	2.90	.40	.30	2.15	4.10
16	4.20	19.20	24.40	11.10	19.40	4.40	6.90	2.60	.30	6.40	2.10	4.15
17	4.10	18.00	24.70	10.20	19.10	4.10	6.10	2.10	.10	5.60	2.00	6.00
18	4.20	17.90	24.40	9.70	16.70	4.00	4.40	1.80	.10	3.90	1.93	7.40
19	4.60	16.70	23.40	9.40	13.70	3.90	3.40	1.40	.00	2.50	1.93	7.30
20	4.70	14.70	22.00	9.00	11.20	3.60	3.30	3.00	.10	1.80	1.93	6.20
21	5.00	14.20	20.70	8.40	9.50	5.30	5.10	2.60	.00	2.10	1.90	5.50
22	7.00	20.15	20.40	7.80	8.40	11.40	8.30	2.40	.00	2.30	1.90	5.20
23	12.65	22.45	19.30	7.40	7.80	11.50	9.90	2.30	.10	2.10	1.90	6.83
24	13.90	24.05	17.60	7.10	7.40	8.10	9.10	2.70	.20	3.70	1.80	11.00
25	13.00	25.80	15.90	6.80	7.30	5.80	7.10	4.20	.40	4.40	1.80	12.50
26	10.80	27.25	14.50	6.70	7.40	4.40	5.70	4.90	.30	4.10	1.90	4.30
27	8.60	28.00	13.40	6.60	11.00	4.10	4.90	4.20	.30	3.80	2.00	9.60
28	7.50	26.40	12.20	6.50	11.40	4.60	4.70	3.10	.80	3.70	2.00	9.30
29	5.90	.....	11.30	6.50	9.37	4.75	4.00	2.60	1.90	3.60	3.90	11.00
30	3.40	.....	10.40	6.50	7.40	4.50	3.90	2.40	1.60	3.70	11.18	11.80
31	3.10	.....	9.80	.....	6.30	.....	4.40	2.40	.....	3.40	.....	10.20

TARBORO STATION ON TAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 50, is on the Atlantic Coast Line bridge crossing the river at Tarboro, North Carolina. The zero of the gage is over the center of the fifth floor beam from the east end of the bridge. The outer rim of the pulley is 3 feet from the zero of the gage, and the distance from the end of the weight to the pointer on the wire is 38.30 feet. The gage reading is zero when the weight touches the bottom of the stream. The river here is a little obstructed by sand bars. The observer is R. H. Williams. The following discharge measurements were made by E. W. Myers during 1897:

January 23, gage height 6.64 feet; discharge, 3,520 second-feet.
February 26, gage height 13.51 feet; discharge, 8,106 second-feet.
March 15, gage height, 18.13 feet; discharge, 12,993 second-feet.
May 17, gage height, 6.30 feet; discharge, 3,058 second-feet.
July 29, gage height, 2.25 feet; discharge, 1,079 second-feet.
October 2, gage height, — 0.65 feet; discharge, 192 second-feet.

Daily gage height, in feet, of Tar River at Tarboro, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	3.10	11.90	4.35	2.65	1.50	0.70	1.80	0.90	—0.60	0.80	2.20
2	3.55	5.50	10.00	4.30	4.10	1.40	.50	1.25	3.00	— .65	1.40	3.10
3	3.60	7.40	8.00	4.00	5.10	2.70	.40	1.20	5.00	— .70	2.00	3.00
4	3.31	8.90	6.90	4.30	5.90	2.20	.30	.70	3.60	— .62	4.60	2.50
5	3.25	10.20	6.20	4.95	5.10	1.75	.20	.50	2.10	— .64	4.40	2.30
6	3.22	10.22	5.60	6.10	3.80	1.50	.40	.45	1.35	— .40	3.00	2.80
7	3.15	9.60	6.60	7.50	3.30	1.35	.30	.40	1.40	— .50	2.10	3.20
8	3.00	10.10	8.55	8.50	3.10	2.00	1.05	1.30	1.00	— .60	1.50	2.80
9	2.90	11.38	10.30	7.40	2.70	2.02	.60	1.00	.70	— .70	1.65	2.40
10	2.60	12.35	11.80	7.80	2.50	1.55	.50	.90	.40	— .60	1.20	2.20
11	2.50	11.10	11.70	11.00	2.40	1.30	1.50	.50	.10	— .50	.80	1.90
12	2.45	8.09	11.10	13.40	2.25	1.35	1.63	.40	— .05	— .52	.90	1.90
13	2.55	7.00	12.80	14.90	2.35	1.15	2.50	.85	— .07	— .50	.70	1.60
14	2.60	6.98	15.00	14.50	3.80	1.10	7.20	.60	— .02	— .51	.50	1.70
15	3.00	7.51	16.50	13.60	5.40	1.10	5.80	.20	.02	— .63	.60	1.90
16	3.35	6.70	17.90	11.50	7.50	1.05	4.70	.15	— .05	— .71	.70	2.10
17	3.43	6.15	19.20	8.60	7.00	.80	2.80	.35	— .21	— .90	.50	2.20
18	3.50	6.30	19.60	6.70	4.60	1.50	2.00	.10	— .20	—1.00	.40	2.90
19	3.40	6.20	19.70	5.70	3.50	.90	1.33	— .10	— .20	— .90	.45	2.60
20	3.35	5.55	18.15	5.00	3.00	.60	1.28	— .08	— .30	— .80	.50	2.00
21	3.40	6.00	16.00	4.30	2.70	.40	1.20	— .08	— .50	— .50	.40	2.10
22	4.30	7.95	13.60	3.90	2.30	2.60	3.70	— .05	— .30	— .55	.45	2.20
23	6.25	9.62	11.30	3.70	1.80	2.10	6.05	— .15	— .40	+ .50	.65	3.30
24	8.30	11.25	9.10	3.50	1.70	1.40	5.80	.50	— .35	.80	.45	5.30
25	6.45	12.15	7.80	3.40	1.80	1.00	4.50	.60	— .40	.70	.40	6.10
26	4.80	13.30	7.00	3.10	1.60	.80	3.30	.62	— .50	.90	.35	4.20
27	4.30	13.75	6.20	3.20	1.50	.70	2.80	.40	— .60	.50	.45	4.00
28	4.40	13.00	5.40	3.00	1.90	.65	2.60	.23	— .65	.70	1.00	4.10
29	4.10	.....	4.90	2.80	2.00	1.10	2.25	.05	— .55	1.50	1.80	5.00
30	3.90	.....	4.70	2.70	1.60	1.09	2.60	.02	— .50	1.60	2.10	4.60
31	3.05	.....	4.50	.....	1.40	.....	2.30	.65	.....	1.30	.....	3.90

SELMA STATION ON NEUSE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 52, is located on the Southern Railway bridge about 3 miles from Selma, North Carolina. The zero of the gage rod is over the center of the fifth floor beam of the first span from the south end of the bridge. The distance from the zero of the gage to the outer rim of the pulley is 4 feet, and the distance from the end of the weight to the pointer on the wire is 41.05 feet. The bed of the river here is sandy and muddy and is liable to change in high water. The course of the river is straight and there is only one pier obstruction. The observer is C. Richardson, Selma, North Carolina. The following discharge measurements were made by E. W. Myers during 1897:

January 24, gage height, 6.45 feet; discharge, 1,810 second-feet.
February 23, gage height, 10.60 feet; discharge, 4,052 second-feet.
March 10, gage height, 7.95 feet; discharge, 2,639 second-feet.
May 18, gage height, 2.40 feet; discharge, 789 second-feet.
July 28, gage height, 1.60 feet; discharge, 694 second-feet.
October 1, gage height, —0.30 foot; discharge, 109 second-feet.

Daily gage height, in feet, of Neuse River at Selma, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.70	3.90	2.60	2.20	6.00	0.80	0.70	0.10	—0.30	0.00	1.80
2	1.40	2.80	3.70	2.50	3.20	4.50	1.20	.60	.10	— .30	.00	1.70
3	1.30	6.70	3.40	2.40	4.00	2.90	.80	.50	.10	— .30	.00	1.50
4	1.20	7.40	3.10	2.90	5.90	2.30	.60	.40	.10	— .30	.45	1.40
5	1.20	8.60	2.80	3.40	3.80	1.70	.50	.20	.20	— .30	.50	2.30
6	1.20	5.00	2.80	10.10	2.20	1.80	.40	.20	.20	— .30	.60	2.30
7	1.20	12.40	5.20	9.70	2.00	3.20	.70	.20	.10	— .30	1.00	2.00
8	1.10	13.20	9.90	5.80	1.90	2.60	.60	.20	.10	— .30	1.00	1.70
9	1.10	13.20	10.50	4.70	1.80	1.90	.60	.20	.10	— .30	1.00	1.30
10	1.10	7.50	8.80	14.50	1.60	1.60	1.20	.20	.10	— .30	.80	1.00
11	1.10	5.70	9.00	13.90	1.60	1.40	1.30	.20	.10	— .30	.80	1.00
12	1.10	4.40	11.20	10.50	2.20	2.10	2.20	.10	.10	— .30	.70	1.20
13	1.20	4.20	15.80	7.00	2.00	1.10	5.50	.10	.10	— .30	.40	1.10
14	1.30	4.40	14.70	5.20	5.00	1.00	5.30	.10	.10	— .30	.40	1.00
15	1.60	4.50	16.50	3.80	3.80	.90	4.80	.10	.10	— .30	.40	1.10
16	1.70	4.80	16.80	3.70	9.60	.80	2.30	.10	.10	— .30	.40	3.00
17	1.70	4.70	15.70	3.50	4.30	.70	1.20	.20	.10	— .40	.40	2.70
18	1.80	4.50	15.00	3.20	2.60	.60	1.10	.20	.10	— .40	.40	1.90
19	2.20	4.40	11.70	2.90	2.30	1.10	1.00	.10	—.10	— .30	.30	1.20
20	2.50	3.00	8.30	2.60	2.00	.50	1.30	.10	—.10	— .30	.30	1.30
21	2.90	3.50	8.20	2.40	1.90	2.20	4.10	.10	—.10	+ .10	.30	2.30
22	8.30	5.50	6.20	2.20	1.80	1.40	5.50	.80	—.10	.40	.30	4.20
23	9.30	10.60	4.60	2.10	1.60	1.10	5.60	1.40	—.10	.10	.20	5.80
24	8.00	11.40	4.20	2.00	1.60	.90	2.50	1.80	—.10	.20	.20	6.00
25	4.30	11.30	3.70	2.00	1.80	2.00	1.50	1.40	—.10	.20	.20	4.50
26	4.00	7.70	3.40	1.90	2.00	1.30	2.30	.90	—.30	.30	.20	3.00
27	3.80	7.30	3.10	1.90	2.40	.80	1.90	.50	—.30	.40	.20	3.50
28	3.40	4.50	3.00	1.90	1.80	.60	1.60	.30	—.30	.30	.20	4.10
29	2.80	.....	2.70	1.80	1.40	.70	1.60	.10	—.30	.30	1.90	4.50
30	2.50	.....	2.60	1.80	1.60	1.30	1.10	.10	—.30	.20	2.30	4.20
31	2.20	.....	2.60	.....	1.50	.....	.80	.10	.....	.00	.....	3.10

FAYETTEVILLE STATION ON CAPE FEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 54, is at the bridge of the Cape Fear and Yadkin Valley Railroad, about a mile east of Fayetteville, North Carolina. The Weather Bureau has a gage fastened to the lower side of the east abutment of the covered highway bridge, this being about 400 feet above the railroad bridge, from which discharge measurements are made. For the lower 29 feet this gage consists of a rod divided into tenths and firmly fastened to the abutment. Above the 29-foot mark a scale is painted on the rock. The observer is Frank Glover, who has charge of the steamboat landing just below the railroad bridge. For his convenience he has placed a subsidiary gage at the steamboat landing reading about the same as the official gage, and from this observations are taken. The following discharge measurements were made by E. W. Myers during 1897:

March 12, gage height, 23.00 feet; discharge, 16,777 second-feet.
July 27, gage height, 7.00 feet; discharge, 2,682 second-feet.
September 30, gage height, 0.70 foot; discharge, 424 second-feet.

Daily gage height, in feet, of Cape Fear River at Fayetteville, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.20	5.50	13.40	7.70	6.10	7.00	5.00	4.70	2.20	0.70	1.90	5.50
2	6.00	5.90	11.70	8.00	10.00	8.60	3.20	3.20	4.60	.70	5.50	6.00
3	5.50	25.00	10.20	7.30	14.40	6.50	2.50	3.00	3.50	.80	9.70	5.10
4	5.50	27.00	9.00	8.00	13.20	5.00	2.00	2.70	3.00	.60	9.30	4.60
5	5.30	19.70	8.50	9.30	9.30	4.20	1.90	2.20	2.50	.70	7.20	4.30
6	5.00	15.00	7.60	27.00	8.00	4.30	3.90	2.60	2.10	.50	5.00	5.10
7	4.80	29.10	9.20	28.30	6.30	7.00	4.20	4.10	1.80	.30	4.00	5.20
8	4.60	36.50	25.60	22.00	5.60	5.50	4.80	6.80	1.50	.20	3.50	4.70
9	4.60	32.00	26.20	15.40	5.00	7.00	4.20	6.20	1.10	.20	2.90	4.10
10	4.40	24.30	20.00	23.50	4.60	7.80	4.00	6.20	1.10	.30	2.60	3.70
11	4.20	17.60	21.40	28.00	4.20	5.50	4.00	5.40	1.10	.60	2.40	3.40
12	4.10	13.00	22.00	22.70	5.20	4.40	3.90	4.30	1.10	.60	2.50	3.30
13	4.00	18.20	29.70	18.30	6.00	4.20	6.00	3.50	.90	.60	2.40	3.30
14	4.50	19.00	32.00	14.30	10.00	3.50	11.10	3.00	.80	.60	2.30	3.00
15	6.00	16.30	36.40	12.80	17.40	3.20	6.00	2.40	.70	.40	2.00	3.00
16	6.40	12.80	37.60	10.20	14.00	3.00	4.60	3.80	.60	.30	2.00	4.00
17	7.80	13.20	37.60	10.00	10.30	2.70	3.20	3.00	.30	.30	1.80	4.90
18	7.00	15.00	29.00	9.80	8.30	3.00	3.20	2.50	.80	.30	1.60	5.20
19	8.50	12.90	23.80	8.40	6.70	3.50	3.80	2.20	.80	.30	1.90	4.50
20	9.60	10.80	19.20	7.70	5.50	4.50	5.50	3.00	.90	.40	1.90	3.90
21	7.80	14.00	18.00	7.00	4.80	4.30	16.50	3.20	1.40	.90	1.70	3.50
22	20.40	24.30	16.60	6.70	4.50	3.50	25.30	5.00	1.40	1.50	1.70	3.50
23	24.55	23.50	13.70	6.30	4.30	3.00	16.40	5.20	1.10	1.60	1.70	4.80
24	16.80	23.50	11.20	5.80	4.20	2.40	12.70	6.50	1.10	1.70	1.50	9.00
25	12.60	24.20	10.00	5.50	4.30	1.80	8.50	5.60	1.10	2.00	1.40	7.80
26	8.50	23.30	9.30	5.50	4.60	4.80	6.10	4.90	1.10	2.20	1.60	5.70
27	7.20	20.40	8.40	5.20	4.50	3.40	7.00	4.00	.90	1.90	1.70	6.00
28	7.00	16.60	8.00	4.70	4.40	2.80	7.30	3.50	1.10	1.90	1.90	10.00
29	6.60	.....	7.40	4.50	4.00	3.70	6.90	2.90	.80	1.70	2.30	9.50
30	5.90	.....	7.20	4.40	4.40	4.00	5.60	2.50	.70	1.90	3.50	7.10
31	5.60	.....	7.20	.....	4.30	.....	5.00	2.50	.....	1.70	.....	5.00

SALISBURY STATION ON YADKIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 57, is at the Southern Railway bridge near Holtsburg, below the mouth of Grants Creek, about 4 miles from Salisbury, North Carolina. The 10-foot mark of the gage rod is opposite the center of the sixth floor beam on the lower side of the first span from the west end. The distance from the zero of the rod to the outside of the pulley wheel is 1.85 feet. The length of the wire rope and weight is 55.10 feet. The post-office address of the observer, H. A. Ragle, is Sapona, North Carolina, the nearest railroad station, Holtsburg, being merely a siding. The locality is reached by wagon from Salisbury. Discharge measurements are made from the lower side of the deck bridge, the zero point being on the left bank. The channel is obstructed by three piers, with large rafts of driftwood lodged against each and sand bars below each. There are also some rocks in the river, and the bottom is rough. The following discharge measurements were made by E. W. Myers during 1897:

February 13, gage height, 4.20 feet; discharge, 10,141 second-feet.
March 20, gage height, 4.45 feet; discharge, 11,837 second-feet.
April 8, gage height, 3.90 feet; discharge, 9,992 second-feet.
August 4, gage height, 2.18 feet; discharge, 3,422 second-feet.
October 6, gage height, 1.40 feet; discharge, 1,300 second-feet.

Daily gage height, in feet, of Yadkin River at Salisbury, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.05	2.50	2.90	2.80	3.50	2.80	2.00	1.90	2.10	1.30	2.10	2.00
2	2.04	2.90	2.80	2.70	4.50	2.70	2.00	1.70	2.10	1.40	2.20	2.00
3	2.02	5.80	2.70	2.80	4.00	2.20	1.90	1.90	2.00	1.30	2.10	2.10
4	2.01	4.30	2.70	3.00	3.20	2.20	2.00	2.10	1.90	1.30	2.30	2.00
5	2.00	3.00	2.60	5.50	2.70	2.60	2.00	2.00	1.90	1.20	2.10	2.60
6	2.00	3.50	2.50	10.20	2.50	2.40	2.10	1.90	1.80	1.40	2.10	2.80
7	2.00	11.10	8.30	6.50	2.40	2.50	2.00	2.50	1.80	1.40	2.10	2.70
8	2.00	7.57	7.50	4.20	2.40	6.80	2.60	1.90	1.80	1.40	2.00	1.80
9	2.00	5.20	5.60	4.30	2.40	5.00	2.90	1.90	1.60	1.40	1.80	1.90
10	2.00	3.75	5.90	4.00	2.30	5.30	2.40	1.90	1.60	1.40	1.80	1.80
11	2.00	3.00	6.10	4.00	2.40	5.00	2.40	1.90	1.60	1.40	1.70	1.80
12	2.00	3.70	5.10	3.20	2.40	4.10	2.00	1.80	1.50	2.00	1.70	1.80
13	2.00	4.20	5.10	3.00	3.00	2.80	4.50	1.80	1.50	8.50	1.70	1.80
14	2.00	3.70	5.10	3.00	5.20	2.80	3.00	1.80	1.50	4.10	1.60	1.80
15	2.08	3.20	6.40	3.10	3.90	2.60	2.40	1.70	1.40	2.30	1.60	2.20
16	2.10	2.79	5.30	3.20	3.10	2.40	2.10	1.70	1.40	2.30	1.60	2.50
17	2.12	2.90	5.20	2.80	2.50	2.30	1.90	2.00	1.30	1.90	1.50	2.20
18	2.50	2.60	4.40	2.80	2.50	2.20	2.40	2.80	1.30	1.80	1.50	2.10
19	2.52	2.60	4.00	2.90	2.50	2.20	3.40	2.30	1.30	1.80	1.50	1.80
20	2.55	.....	4.40	2.80	2.40	2.70	3.70	1.90	1.20	2.10	1.40	1.80
21	3.40	.....	4.30	2.70	2.40	2.30	3.00	1.60	1.30	4.10	1.40	2.00
22	4.60	5.60	3.90	2.60	2.20	2.10	3.20	1.80	1.40	3.00	1.20	2.10
23	3.65	5.00	3.40	2.60	2.10	2.10	2.10	2.30	1.50	2.10	1.40	2.00
24	2.85	9.50	3.00	2.40	2.20	1.90	2.30	2.20	1.80	1.90	1.40	2.00
25	2.58	6.70	3.00	2.30	3.60	1.90	3.00	2.10	1.50	1.90	1.40	2.00
26	2.45	4.70	2.90	2.40	3.00	1.80	2.10	2.10	1.50	1.90	1.20	1.90
27	2.30	3.50	2.80	2.40	2.70	1.90	3.40	2.00	1.50	1.90	3.10	2.00
28	2.22	3.00	3.00	2.40	2.30	1.90	3.30	1.90	1.30	1.80	3.20	2.00
29	1.90	.....	2.80	2.40	2.40	2.00	2.50	2.20	1.30	1.80	3.00	2.00
30	1.88	.....	2.70	2.50	2.40	2.00	2.10	2.20	1.30	1.70	2.70	1.90
31	2.13	.....	2.80	.....	2.30	.....	1.90	2.10	.....	1.90	.....	1.90

NORWOOD STATION ON YADKIN (PEEDEE) RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 60, is near Blalocks Ferry, 1 mile above Richland Creek and about 2 miles from Norwood, North Carolina. The gage is a vertical rod divided into feet and tenths, and is securely spiked and braced to an overhanging tree near the ferry. The rod is referred to a bench mark consisting of a large nail driven into a notch cut in the root of a birch tree about 50 feet northwest of the rod, and the tree is immediately in front of the turn of the road that leads to the ferry. The zero of the gage rod is 5.93 feet below the elevation of the bench mark. The river here is broad and shallow, with smooth bottom of sand and small rocks, giving a good section for discharge measurements, which are taken from the ferryboat. The observer is W. B. Nichols, Norwood, North Carolina. The banks and bed are, for the most part, hard and permanent and the depth and current of the water very uniform. The chief variation is at a point about 100 feet from the right bank, where the water is deep and very sluggish. The following discharge measurements were made by E. W. Myers and others during 1897:

February 10, gage height, 3.32 feet; discharge, 9,607 second-feet.
March 21, gage height, 3.80 feet; discharge, 11,710 second-feet.
August 4, gage height, 1.65 feet; discharge, 3,392 second-feet.
October 6, gage height, 1.00 feet; discharge, 1,508 second-feet.
October 25, gage height, 1.48 feet; discharge, 2,715 second-feet.

Daily gage height, in feet, of Yadkin River at Norwood, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	1.90	2.50	2.40	2.40	2.10	1.70	1.70	1.30	1.00	1.60	2.20
2	1.70	2.70	2.30	2.30	3.80	2.10	1.60	1.50	1.50	1.00	1.70	2.00
3	1.60	3.30	2.30	2.40	4.30	1.90	1.60	1.60	1.30	1.10	1.80	1.80
4	1.60	3.50	2.20	2.60	2.90	1.80	1.90	1.60	1.30	1.10	1.80	1.70
5	1.50	2.60	2.20	6.70	2.60	1.90	1.70	1.70	1.20	1.00	1.70	2.00
6	1.50	5.50	2.60	8.50	2.30	2.40	1.40	1.50	1.20	1.00	1.50	2.00
7	1.70	8.20	6.90	6.00	2.20	2.30	1.90	2.10	1.20	1.00	1.50	2.00
8	1.70	9.20	6.80	3.80	2.10	2.40	2.10	2.50	1.10	1.00	1.40	1.80
9	1.60	4.30	4.80	4.20	2.10	4.30	1.80	2.20	1.20	1.10	1.40	1.80
10	1.50	3.40	4.30	4.20	2.10	3.40	1.70	2.00	1.20	1.00	1.30	1.70
11	1.50	2.80	5.20	3.50	2.30	3.40	1.90	1.70	1.20	1.00	1.30	1.70
12	1.50	3.10	5.40	2.90	2.50	2.50	1.80	1.60	1.10	1.10	1.40	1.40
13	1.50	3.90	4.90	2.70	2.90	2.30	3.10	1.50	1.10	3.70	1.30	1.40
14	1.60	3.40	5.40	2.50	3.50	2.20	2.80	1.50	1.00	3.80	1.30	1.30
15	1.60	2.80	6.50	2.50	3.60	2.10	2.50	1.40	1.00	2.20	1.30	1.80
16	1.70	2.60	5.00	2.40	2.80	2.10	1.70	1.40	.90	1.90	1.30	1.90
17	1.70	2.70	4.90	2.70	2.40	2.10	1.60	1.50	.80	1.60	1.20	2.00
18	2.00	2.40	3.90	2.50	2.30	1.80	2.10	2.30	.90	1.30	1.40	1.80
19	2.30	2.30	3.50	2.30	2.10	1.90	1.80	2.00	1.00	1.20	1.30	1.70
20	2.50	2.10	3.60	2.20	2.10	1.90	2.50	1.70	1.10	1.20	1.30	1.70
21	4.50	3.70	3.80	2.30	2.00	1.80	4.50	1.50	1.20	1.40	1.30	1.60
22	4.40	3.40	3.30	2.20	2.00	2.10	3.50	2.40	1.10	2.30	1.20	1.80
23	3.50	4.30	3.00	2.10	2.10	2.10	2.70	1.50	1.10	1.96	1.30	1.40
24	2.50	7.70	2.80	2.20	2.00	2.00	2.40	2.00	1.00	1.60	1.20	1.70
25	2.30	6.20	2.60	2.10	2.20	1.90	2.00	1.90	1.20	1.50	1.20	1.70
26	2.10	3.50	2.60	2.10	3.10	1.80	2.10	1.80	1.50	1.50	1.20	2.00
27	2.00	2.90	2.50	2.30	2.20	1.60	2.40	1.90	1.30	1.40	1.50	2.40
28	1.90	2.50	2.50	2.20	2.00	1.60	3.50	1.70	1.20	1.40	3.00	2.70
29	1.80	.....	2.30	2.10	1.90	1.90	2.30	1.60	1.10	1.40	2.50	2.40
30	1.80	.....	2.30	2.30	2.00	1.70	1.90	1.40	1.10	1.30	2.40	2.00
31	.....	.....	2.40	.....	2.00	.....	1.70	1.40	.....	1.40	.....	1.90

CATAWBA STATION ON CATAWBA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 64, is located at the Southern Railway bridge about one-half a mile from Catawba, North Carolina. The zero of the gage rod is 23 feet east of the west end of the second span of the bridge, and the distance from the zero of the gage rod to the outer rim of the pulley is 3 feet. The distance from the end of the weight to the marker on the wire is 35.58 feet, the reading being zero when the weight touches bottom. The river is straight for several hundred yards above and below the bridge, and the current velocity is evenly distributed across the stream. The observer is E. M. Brawley, Catawba, North Carolina. Discharge measurements are made from a plank walk underneath the bridge. The channel is obstructed by three piers and riprap and by two trestles of false work. The section is otherwise good. The following discharge measurements were made by E. W. Myers and others during 1897:

February 8, gage height, 5.51 feet; discharge, 9,711 second-feet.
August 3, gage height, 1.90 feet; discharge, 1,358 second-feet.
October 5, gage height, 1.60 feet; discharge, 775 second-feet.
October 26, gage height, 1.82 feet; discharge, 1,279 second-feet.

Daily gage height, in feet, of Catawba River at Catawba, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.82	2.25	2.75	2.85	6.00	2.15	2.00	1.95	1.70	1.60	2.00	2.15
2	1.85	4.00	2.45	2.90	4.00	2.10	2.00	1.85	1.70	1.60	3.00	2.10
3	1.88	3.65	2.35	4.00	3.90	2.05	2.00	1.80	1.65	1.60	2.50	2.05
4	1.82	3.10	2.30	4.25	3.45	2.00	2.00	2.30	1.65	1.60	2.00	2.05
5	2.22	2.60	2.25	16.00	3.20	2.75	2.05	2.90	1.70	1.60	1.90	2.00
6	2.00	15.90	8.27	8.20	2.90	2.50	2.30	3.00	1.70	1.60	1.85	2.00
7	1.95	9.62	4.50	5.75	2.80	2.90	2.20	2.60	1.70	1.60	1.85	1.95
8	1.90	5.82	2.90	3.90	2.70	3.40	3.30	2.50	1.70	1.60	1.85	1.90
9	1.90	3.90	5.50	4.00	2.70	3.40	2.80	2.60	1.70	1.60	1.75	1.90
10	1.95	3.60	6.00	3.80	2.75	2.90	2.50	2.50	1.70	1.70	1.75	1.90
11	1.95	3.40	5.50	3.60	2.80	2.65	2.30	2.40	1.70	3.00	1.70	1.90
12	1.95	4.65	5.00	3.25	2.80	2.40	2.25	2.25	1.70	8.00	1.70	1.90
13	1.95	4.10	6.20	3.02	4.20	2.35	2.40	2.10	1.70	4.00	1.70	1.85
14	1.95	3.50	6.00	3.00	3.30	2.30	2.30	2.00	1.70	2.50	1.70	1.85
15	1.95	3.40	5.90	3.05	2.90	2.25	2.25	2.00	1.70	2.00	1.70	1.85
16	2.00	4.20	5.80	3.02	2.50	2.20	2.25	1.90	1.70	1.90	1.70	1.85
17	2.00	3.80	5.50	3.00	2.45	2.35	2.30	1.85	1.70	1.90	1.70	1.85
18	2.20	7.80	4.40	2.95	2.45	2.40	2.30	1.80	1.70	2.50	1.70	1.85
19	2.00	2.75	4.00	2.85	2.40	2.50	2.25	1.80	1.70	2.40	1.70	1.85
20	2.20	2.85	4.75	2.85	2.40	2.30	2.30	1.80	1.70	2.25	1.70	1.90
21	4.45	3.20	4.30	2.80	2.40	2.20	2.90	1.80	1.70	2.00	1.70	2.50
22	3.80	3.10	3.70	2.82	2.30	2.15	2.75	1.75	1.80	1.90	1.70	2.50
23	3.25	10.10	3.40	2.80	2.25	2.10	2.75	1.75	2.10	1.80	1.70	2.40
24	2.45	7.60	3.20	2.78	2.20	2.10	2.80	1.75	2.05	1.75	1.70	2.30
25	2.30	4.25	3.00	2.75	2.20	2.10	2 75	1.75	2.00	1.75	1.70	2.25
26	2.20	3.60	2.95	2.75	2.50	2.05	2.60	1.70	2.00	1.80	2.50	2.25
27	2.15	3.05	2.85	2.75	2.30	2.05	2.70	1.70	1.95	1.80	3.00	2.20
28	2.00	2.90	2.80	2.75	2.25	2.00	2.60	1.70	1.90	1.80	2.50	2.20
29	1.85	.....	2.82	2.80	2.20	2.00	2.50	1.70	1.80	1.80	2.25	2.15
30	2.50	.....	2.85	3.90	2.20	2.00	2.35	1.70	1.70	1.75	2.20	2.15
31	2.35	.....	2.85	.....	2.15	.....	2.15	1.70	.....	1.70	.....	2.00

ROCKHILL STATION ON CATAWBA RIVER.

This station, described in the Eighteen Annual Report, Part IV, page 61, is located at the bridge of the Southern Railway 3 miles south of Fort Mill, South Carolina. The gage is fastened to the upper side of the guard rail, the 2-foot mark of the rod being about the center of the second vertical of the second truss from the south end of the bridge. The distance from the zero of the rod to the outside edge of the pulley wheel is 1.30 feet, and the length of wire rope to the end of the weight is 52.96 feet. The observer is W. A. Morris, Rockhill, South Carolina. This station is reached from Rockhill by team. The bridge is high and long; the bed of the stream is on solid rock and is very rough. The current is at an angle with the bridge, and is swift, so that altogether the section is very poor. The following discharge measurements were made by E. W. Myers and others during 1897:

February 9, gage height, 5.00 feet; discharge, 9,711 second-feet.
April 6, gage height, 12.10 feet; discharge, 46,040 second-feet.
August 15, gage height, 1.55 feet; discharge, 2,006 second-feet.
October 8, gage height, 1.21 feet; discharge, 1,532 second-feet.
November 1, gage height, 1.45 feet; discharge, 2,619 second-feet.

Daily gage height, in feet, of Catawba River at Rockhill, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.85	2.60	2.50	2.70	2.00	1.70	1.45	1.40	1.20	1.40	1.85
2	1.75	2.70	2.50	2.40	2.90	1.90	1.60	1.45	1.40	1.20	1.50	1.60
3	1.70	3.30	2.40	2.40	4.40	1.90	1.50	1.50	1.40	1.20	1.55	1.70
4	1.70	3.30	2.30	2.60	3.20	1.80	1.50	1.60	1.40	1.20	1.95	1.80
5	1.70	2.70	2.30	10.30	2.70	2.60	1.60	1.60	1.40	1.20	1.70	1.85
6	1.70	8.50	2.30	13.30	2.50	2.40	1.80	1.90	1.30	1.20	1.60	1.90
7	1.90	14.75	7.70	7.00	2.40	2.20	1.60	2.20	1.30	1.20	1.50	1.80
8	1.80	10.20	7.60	4.00	2.30	4.30	2.30	2.45	1.30	1.20	1.50	1.70
9	1.80	5.00	4.50	3.50	2.30	3.60	2.30	2.10	1.30	1.20	1.50	1.70
10	1.70	3.60	4.80	3.30	2.20	3.00	2.20	1.90	1.30	1.20	1.50	1.60
11	1.70	3.20	5.70	3.50	2.20	2.70	2.00	4.70	1.25	1.30	1.50	1.60
12	1.70	3.50	5.30	3.00	2.20	2.30	1.80	2.50	1.20	1.65	1.45	1.60
13	1.70	3.70	5.60	2.90	2.40	2.30	2.40	1.80	1.20	4.80	1.40	1.60
14	1.70	3.50	6.40	2.80	4.20	2.00	2.30	1.65	1.20	2.90	1.40	1.55
15	1.70	3.20	7.10	2.70	2.90	2.00	2.10	1.60	1.20	2.00	1.40	1.60
16	1.80	3.00	5.10	2.80	2.45	2.00	1.70	1.90	1.20	1.65	1.40	1.70
17	1.80	2.90	5.00	2.80	2.25	1.90	1.55	1.70	1.20	1.50	1.40	1.90
18	1.90	2.70	4.50	2.60	2.20	2.00	1.70	1.60	1.20	1.45	1.40	1.75
19	1.90	2.50	3.70	2.50	2.20	2.00	1.60	1.70	1.20	1.40	1.40	1.70
20	2.00	2.50	4.20	2.45	2.10	1.90	2.00	1.60	1.20	1.45	1.40	1.65
21	3.60	3.30	4.10	2.40	2.20	2.20	2.35	1.50	1.50	1.50	1.40	1.70
22	3.70	3.00	3.60	2.35	2.00	1.90	5.25	1.60	1.30	2.30	1.40	1.90
23	3.10	3.00	3.20	2.30	2.00	1.70	2.60	1.60	1.25	1.80	1.40	2.00
24	2.50	7.80	3.00	2.30	2.00	1.65	2.00	1.80	1.25	1.60	1.40	2.00
25	2.30	4.80	2.90	2.30	2.10	1.60	1.70	2.00	1.50	1.50	1.40	1.90
26	2.10	3.50	2.70	2.20	2.10	1.90	1.60	1.70	1.60	1.50	1.40	1.85
27	2.00	3.10	2.60	2.30	2.00	1.70	2.30	1.60	1.40	1.50	2.40	2.10
28	2.00	2.70	2.50	2.40	1.90	1.70	2.00	1.50	1.35	1.45	2.70	2.20
29	1.90	.....	2.50	2.20	1.90	1.70	1.80	1.50	1.30	1.45	2.15	2.10
30	1.70	.....	2.40	2.20	2.00	1.70	1.60	1.45	1.30	1.45	2.10	1.90
31	1.70	.....	2.55	.....	1.90	.....	1.50	1.45	.....	1.40	.....	1.80

GAFFNEY STATION ON BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 65, is at the Southern Railway bridge about 3 miles from Gaffney, South Carolina. The zero of the gage is 18 feet east of the west end of the third span of the bridge from the east. The distance from the zero of the gage to the rim of the pulley is 2.5 feet, and that from the end of the weight to the pointer on the wire is 50.71 feet. The river here is straight for several hundred yards above and below the bridge, but the section is not a good one, as the right bank is subject to overflow in very high water. This station is reached from Blacksburg, South Carolina. The readings of river heights are made at the railroad bridge, where the section is poor. Measurements of discharge are made from the ferryboat located one-fourth mile above. There the section is very good. The bottom is sandy, but the current is sluggish at the left bank. The observer is J. M. Gaffney. The following discharge measurements were made by E. W. Myers and others during 1897:

March 9, gage height, 2.85; discharge, 4,364 second-feet.
April 7, gage height, 3.49 feet; discharge, 5,324 second-feet.
August 6, gage height, 1.65 feet; discharge, 1,297 second-feet.
October 9, gage height, 0.92 foot; discharge, 829 second-feet.
October 31, gage height, 1.38 feet; discharge, 861 second-feet.

Daily gage height, in feet, of Broad River at Gaffney, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.84	1.25	1.19	2.25	3.24	3.09	3.13	1.89	1.79	0.95	1.03	2.43
2	.89	2.12	1.87	2.09	4.32	3.05	3.11	1.79	1.74	.92	1.69	2.44
3	.87	2.59	1.88	2.07	4.01	3.31	3.05	2.25	1.33	1.08	1.85	2.46
4	.88	2.12	1.94	2.11	3.69	3.33	3.17	2.32	1.31	.92	1.25	2.52
5	.87	1.82	1.95	8.97	3.55	3.26	3.46	2.19	1.25	1.03	1.21	1.93
6	.93	8.69	3.87	5.95	3.27	3.45	3.21	2.25	1.23	1.05	1.19	1.92
7	.94	7.48	6.00	3.85	3.29	3.51	4.09	2.32	1.21	.89	1.25	1.42
8	.91	4.05	3.32	3.29	3.28	5.45	3.68	2.75	1.03	1.02	1.08	1.23
9	.87	3.19	2.87	3.09	3.64	3.29	4.01	2.22	1.01	.92	1.06	1.46
10	.91	2.82	3.39	3.25	3.61	3.09	3.64	2.09	1.12	.79	1.04	1.31
11	.87	2.55	3.69	2.81	3.71	3.03	3.37	2.07	1.02	.81	1.03	1.21
12	.96	2.75	3.94	2.54	3.60	3.09	3.01	2.19	.95	4.19	1.01	1.35
13	.92	2.97	4.65	2.49	3.69	3.14	4.07	2.08	.80	2.91	1.02	1.19
14	.87	2.69	4.52	2.81	3.80	3.29	3.28	1.82	1.00	1.59	1.11	1.21
15	.89	2.45	4.81	2.39	3.55	2.89	3.11	1.91	.89	1.39	1.13	1.59
16	.85	2.28	3.64	2.54	3.73	2.81	3.09	1.99	.82	1.18	1.25	1.35
17	.86	2.24	3.77	2.31	3.39	2.65	3.02	2.01	.92	1.29	1.41	1.25
18	.92	2.11	3.11	2.28	3.09	3.05	3.11	1.69	.96	1.31	1.31	1.38
19	1.15	1.99	2.81	2.05	3.19	3.41	3.05	1.55	.95	1.28	1.28	1.36
20	1.09	1.92	3.81	2.07	3.39	3.61	2.08	1.57	.89	1.25	1.32	1.41
21	2.05	2.27	3.22	2.02	3.24	3.59	2.49	1.41	1.19	1.52	1.01	1.38
22	2.32	2.11	2.85	1.98	3.33	3.42	3.54	1.51	.92	1.41	.98	1.42
23	1.79	2.24	2.62	1.97	3.20	3.28	2.29	1.59	1.39	1.15	1.02	1.68
24	1.58	3.73	2.52	2.14	3.09	3.19	2.08	2.39	1.30	1.25	1.29	1.79
25	1.62	2.67	2.39	2.98	3.25	3.11	2.21	1.61	1.09	1.23	1.41	1.59
26	1.47	2.33	2.29	2.92	3.35	3.02	2.04	1.38	1.02	1.22	1.35	1.87
27	1.39	2.16	2.21	3.02	3.11	3.04	2.29	1.85	.85	1.24	2.51	2.01
28	1.35	2.08	2.16	2.97	3.18	3.42	2.34	1.81	1.25	1.22	2.41	2.09
29	1.25	.....	2.09	2.91	3.21	3.43	2.05	1.82	1.08	1.21	2.39	1.62
30	1.36	.....	1.89	3.17	3.13	3.11	2.01	1.42	1.02	1.23	2.45	1.58
31	1.52	.....	2.13	.....	3.21	.....	2.02	1.81	.....	1.05	.....	1.51

ALSTON STATION ON BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 67, is located at the Southern Railway bridge, about 200 yards from Alston, South Carolina. The zero of the gage is over the center of the fourth floor beam of the second span from the east end of the bridge. The outer rim of the pulley is 4 feet from the zero of the gage, and the distance from the end of the weight to the pointer on the wire is 42.65 feet, the gage reading zero when the end of the weight touches bottom. The section here is not a very good one, being broken by the foundations of an old bridge crossing at the same place as the present one, and the bottom is soft and muddy. The river is straight for a long distance above and below the station, and the current velocity is fairly uniform all the way across. The observer is D. R. Elkin, Alston, South Carolina. The following discharge measurements were made by E. W. Myers and A. P. Davis during 1897:

August 17, gage height, 2.76 feet; discharge, 2,515 second-feet.
November 2, gage height, 2.90 feet; discharge, 2,729 second-feet.

Daily gage height, in feet, of Broad River at Alston, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.01	3.10	4.62	7.00	4.70	3.45	3.71	2.84	2.51	3.55	2.47	3.86
2	3.05	6.50	4.18	6.48	5.61	3.40	3.33	2.60	5.76	2.43	2.97	3.57
3	3.04	7.12	4.20	6.90	6.27	3.50	3.10	2.54	3.64	2.42	3.88	3.56
4	3.01	8.91	4.10	7.70	5.40	3.40	3.05	3.42	3.25	2.23	4.10	3.55
5	2.93	10.00	3.96	14.39	4.45	3.42	4.75	3.03	2.91	2.13	3.35	3.62
6	3.09	17.03	5.66	18.82	4.32	6.70	4.15	3.31	2.62	2.40	2.91	3.76
7	3.11	21.97	12.10	14.40	4.10	7.27	3.92	4.56	2.35	2.53	3.15	3.68
8	3.00	19.03	8.72	10.66	3.90	14.20	3.75	5.20	2.53	2.34	3.00	3.62
9	3.00	12.00	6.75	9.50	3.95	13.64	3.59	3.20	2.51	2.50	2.80	3.80
10	2.89	7.00	5.80	6.83	3.98	9 71	3.95	3.35	2.61	2.43	3.11	3.45
11	2.75	5.50	7.50	6.12	4.10	9.03	3.64	3.11	2.60	2.65	3.00	3.16
12	2.80	9.75	7.10	5.68	3.85	4.50	3.70	3.28	2.45	5.72	2.90	3.15
13	2.97	9.10	11.04	5.43	3.65	4.00	3.70	3.15	2.31	8.93	2.91	3.10
14	3.10	8.50	13.00	5.23	5.44	4.15	3.45	2.98	2.10	7.14	2.90	3.00
15	3.14	5.60	14.40	5.10	4.68	3,90	3.31	4.10	2.37	4.78	2.86	3.45
16	3.00	7.25	11.40	5.10	4.00	3.74	3.30	3.89	2.00	3.50	2.70	3.45
17	3.01	6.23	9.70	4.90	4.03	3.45	3.08	2.89	2.21	3.34	2.78	3.50
18	3.05	5.02	9.00	4.65	3.63	3.42	3.76	2.96	2.24	2.70	2.76	3.30
19	3.76	4.03	7.02	4.47	3.60	3.31	3.15	3.01	2.31	2.60	2.71	3.07
20	3.55	4.50	7.80	4.31	3.51	3.00	5.10	2.85	2.21	3.10	2.86	3.07
21	8.65	5.75	7.85	4.35	3.50	3.21	7.40	2.71	2.40	3.70	2.83	3.00
22	9.52	5.50	6.81	4.20	3.42	3.30	5.71	8.20	3.10	3.47	2.82	3.50
23	6.65	6.70	6.15	4.30	3.51	3.51	4.82	5.04	3.41	3.31	2.79	4.08
24	5.63	6.23	5.96	4.00	3.98	3.73	3.80	3.35	3.83	3.30	2.75	3.85
25	5.03	7.10	5.32	4.01	3.65	4.40	3.61	3.26	3.80	3.00	3.00	3.60
26	4.00	5.70	5.00	4.05	3.41	3.50	3.06	3.11	3.16	2.77	3.21	3.30
27	3.75	5.30	4.81	3.92	3.40	3.55	3.90	3.00	2.98	3.03	3.05	4.50
28	3.55	4.55	4.52	4.17	3.30	5.81	4.01	3.10	2.55	2.90	4.20	4.76
29	3.31	.....	4.23	3.89	3.21	3.70	3.65	2.85	2.58	2.77	5.56	4.12
30	3.02	.....	4.40	3.85	3.28	3.91	3.15	2.73	2.71	2.91	5.12	3.90
31	3.20	.....	4.90	.....	3.30	.....	2.95	2.80	.....	2.50	.....	3.74

WATERLOO STATION ON SALUDA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 68, is 1 mile below the mouth of Reedy River, at the Port Royal and Western Carolina Railroad bridge, about 3 miles from Coronaca station, South Carolina. The zero of the gage is over the center of the sixth floor beam of the first span from the east end of the bridge. The distance from the zero of the gage to the outer rim of the pulley is 2.75 feet, and that from the end of the weight to the pointer on the wire is 47.0 feet. The river here is straight for several hundred yards above and below the bridge. The bottom is of sand and mud and seemingly liable to change by high water, and the right bank is subject to overflow. The observer is R. N. Cunningham, Waterloo, South Carolina. The locality is reached from Greenwood, South Carolina. The channel is broken by one pier and the bottom is muddy, but with these exceptions the section is excellent. Discharge measurements are made from the railroad bridge. The following discharge measurements were made, the first by E. W. Myers and the next by A. P. Davis, during 1897:

August 17, gage height, 3.35 feet; discharge, 665 second-feet.
November 2, gage height, 4.31 feet; discharge, 1,242 second-feet.

Daily gage height, in feet, of Saluda River at Waterloo, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.35	4.75	4.30	6.25	8.35	3.55	4.75	2.80	3.75	3.30	3.20	4.85
2	4.50	7.35	4.80	6.00	9.30	3.70	4.65	2.68	3.75	4.05	4.50	4.75
3	3.70	7.70	5.25	6.55	6.05	5.70	4.30	3.50	3.50	2.85	5.13	4.25
4	4.00	6.20	5.25	8.00	5.50	4.85	3.70	3.60	4.35	2.30	4.77	4.80
5	4.35	5.35	5.05	12.10	5.30	5.25	6.20	3.50	3.20	3.95	4.60	4.00
6	4.40	15.70	8.30	13.95	5.20	6.57	4.15	4.05	2.50	3.80	4.60	4.40
7	4.35	16.58	10.05	17.00	5.00	5.75	4.20	3.75	3.40	2.64	3.60	4.10
8	4.35	14.30	7.75	8.70	5.20	10.35	4.82	3.35	4.00	3.58	2.85	3.95
9	4.40	7.95	6.20	8.05	5.65	12.25	3.85	3.05	3.55	3.00	4.50	3.95
10	3.55	6.40	5.80	7.80	5.15	6.40	4.85	3.55	3.10	3.45	4.35	4.58
11	3.75	8.90	6.00	7.15	4.60	5.55	4.10	3.85	3.25	3.95	4.35	4.68
12	4.30	9.05	9.30	6.75	4.50	5.25	3.10	4.30	3.18	4.50	4.10	3.60
13	4.40	8.25	10.35	6.25	5.10	5.50	5.70	4.20	2.40	7.30	4.30	3.80
14	4.95	7.25	12.60	6.20	5.00	4.20	3.90	4.25	4.00	5.15	4.00	4.75
15	5.85	5.50	12.40	5.70	5.35	4.00	3.75	3.15	3.90	4.85	2.85	4.65
16	4.60	6.35	9.50	6.00	5.60	7.35	3.75	2.55	3.17	4.55	4.15	4.50
17	3.95	6.00	8.35	5.80	4.40	4.15	5.00	4.15	2.90	3.40	4.35	4.75
18	4.65	5.65	7.55	6.25	4.25	4.90	3.90	4.25	2.72	2.50	4.30	4.70
19	4.95	5.60	6.80	5.70	4.15	4.85	3.70	3.75	3.10	3.75	4.15	3.65
20	5.10	5.35	8.40	5.40	4.45	5.00	4.00	4.40	2.40	4.40	3.95	3.40
21	10.80	6.15	8.10	5.15	4.90	3.50	3.70	6.10	3.45	4.55	3.95	4.00
22	8.55	5.80	7.00	5.10	4.85	3.75	3.90	5.35	3.35	4.50	2.70	4.20
23	5.70	7.45	6.45	5.07	5.20	4.10	4.05	3.20	4.75	4.45	3.85	4.90
24	5.60	6.50	6.15	5.40	3.55	4.10	4.05	4.40	4.90	3.55	4.28	3.95
25	4.80	6.55	6.00	6.35	4.00	4.10	4.15	3.35	4.52	3.40	4.20	3.45
26	4.40	6.00	5.60	4.90	4.85	4.15	3.30	4.20	3.58	4.50	4.12	3.65
27	4.35	5.60	9.55	4.80	3.95	3.20	4.00	4.35	2.75	4.20	5.76	3.55
28	3.95	6.70	6.35	4.75	4.80	3.30	3.65	3.50	3.78	3.80	5.75	4.85
29	4.05	.....	5.00	4.65	3.85	4.30	3.60	3.15	3.80	3.95	5.05	4.75
30	4.50	.....	5.10	4.85	5.10	3.75	4.60	2.50	3.55	3.50	5.25	4.65
31	4.20	.....	5.70	.....	3.25	.....	5.00	3.50	.....	3.25	.....	4.77

CALHOUN FALLS STATION ON SAVANNAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 73, is at the Seaboard Air Line bridge across the Savannah River above the mouth of Beaverdam Creek and below Rocky River, and about 3 miles west of the town of Calhoun Falls, South Carolina. The river here is divided into two channels by a large island, containing several hundred acres. The east channel is a good section at ordinary stages, but at lowest water the current is very sluggish. The west channel, which is the main river, is obstructed by some very small islands and old cofferdams about the two piers; otherwise the section is excellent. Peter Pfeiffer, a farmer, is the observer.

The wire gage is on the west channel, center span. The rod is 14 feet long, and is nailed to guard rail on east side of pulley on downstream side of bridge. The center of the 3-inch pulley is 193 feet from the initial point, and is 55.20 feet gage height. Zero point on the rod is 10 feet from the center of the pulley. The wire cable from bottom of weight to the index is 65.40 feet. One bench mark on the top of the iron stringer under the cross-ties near the gage is 54.0 feet above the datum of the gage. The other is on the top of the east end of the pier, west channel, and is 30.85 feet above zero of gage. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

January 20, gage height, 2.90 feet; discharge, 4,204 second-feet.
April 28, gage height, 3.21 feet; discharge, 6,446 second-feet.
June 12, gage height, 2.80 feet; discharge, 4,469 second-feet.
September 29, gage height, 1.90 feet; discharge, 1,693 second-feet.
November 3, gage height, 2.92 feet; discharge, 3,812 second-feet.

Daily gage height, in feet, of Savannah River at Calhoun Falls, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.80	3.00	5.40	3.80	2.20	2.80	2.50	2.20	1.80	2.55	2.80
2	2.40	5.20	2.95	6.90	5.65	2.15	2.65	2.40	2.40	1.80	3.40	2.70
3	2.40	4.00	2.80	5.20	4.30	3.05	2.55	2.35	2.30	1.85	3.05	2.85
4	2.40	3.60	2.80	4.75	3.95	4.40	2.40	2.25	2.25	1.85	2.70	3.00
5	2.35	3.25	2.75	11.65	3.85	4.10	2.30	2.10	2.05	1.80	2.55	2.90
6	2.35	6.00	2.65	13.35	3.80	3.10	3.05	2.65	2.00	1.75	2.45	2.75
7	2.30	8.55	6.80	8.15	3.70	2.95	2.50	2.95	1.95	1.75	2.35	2.70
8	2.25	7.20	4.65	4.95	3.65	3.05	2.40	2.90	1.95	1.70	2.25	2.60
9	2.25	5.05	4.20	4.05	3.40	3.25	2.65	2.70	1.90	1.65	2.20	2.55
10	2.25	4.10	4.00	4.00	3.25	3.05	2.45	2.60	1.85	1.75	2.20	2.55
11	2.20	3.85	4.40	4.15	3.15	2.95	2.50	2.40	1.80	2.25	2.15	2.50
12	2.20	5.15	5.50	4.10	3.05	2.80	2.55	2.30	1.80	2.65	2.10	2.40
13	2.30	4.40	7.75	4.00	3.00	3.00	3.25	2.25	1.85	2.40	2.10	2.35
14	3.05	4.10	7.25	3.95	3.05	2.85	2.65	2.20	1.80	2.25	2.05	2.95
15	2.75	4.00	6.00	3.95	3.10	2.80	2.55	2.15	1.80	2.20	2.00	2.80
16	2.60	4.05	5.20	3.85	3.15	3.00	2.45	2.20	1.75	2.15	2.00	2.70
17	2.55	3.95	4.15	3.80	3.10	3.05	2.50	2.25	1.75	2.10	2.05	2.65
18	3.35	3.80	3.85	3.75	3.05	2.95	3.90	2.20	1.70	2.15	2.00	2.55
19	3.10	3.65	3.50	3.65	3.00	2.85	3.30	2.30	1.70	2.40	2.00	2.50
20	2.90	3.70	4.00	3.50	2.95	2.80	3.10	2.25	1.75	3.05	1.95	2.45
21	5.40	3.50	5.35	3.40	2.90	2.70	4.05	2.20	1.75	2.60	1.95	2.50
22	3.95	3.35	4.40	3.35	2.90	2.65	3.45	2.70	1.85	2.40	1.90	2.65
23	3.60	4.05	4.10	3.30	2.85	2.55	3.00	2.60	2.75	2.35	1.90	2.60
24	3.20	3.80	4.00	3.25	2.75	2.55	2.75	2.40	2.25	2.30	1.85	2.55
25	3.10	4.00	3.90	3.25	2.70	2.45	2.65	2.30	2.05	2.25	1.85	2.50
26	3.00	3.90	3.65	3.30	2.60	2.50	2.95	2.25	2.00	2.30	2.00	2.50
27	2.95	3.45	3.05	3.25	2.55	2.40	3.50	2.20	2.00	2.25	3.25	2.40
28	2.95	3.20	3.40	3.20	2.40	2.30	3.00	2.15	1.95	2.20	3.05	2.40
29	2.90	.....	3.25	3.25	2.35	3.50	2.90	2.10	1.90	2.20	2.95	2.35
30	2.90	.....	3.25	3.40	2.25	2.95	2.70	2.00	1.85	2.15	2.85	2.35
31	2.75	.....	3.30	.....	2.20	.....	2.55	2.05	.....	2.10	.....	2.30

CARLTON STATION ON BROAD RIVER.

This station is located on the railroad bridge of the Seaboard Air Line, 3 miles east of Carlton, Georgia, and 3 miles above the mouth of South Fork. The iron bridge is 250 feet long and is approached on each side by wood trestles. The banks are both liable to overflow to the extent of the trestles. The initial point for sounding is the end of iron bridge at right bank, upstream. The rod of the wire gage is fastened to outside of guard rail on the upstream side of bridge. Its zero is 37.0 feet from initial point and 4.0 feet from center of pulley. Bench mark is top of upstream iron girder under cross-ties at 30 feet from initial point and is 51.0 feet above datum. Center of pulley is 52.20 feet above datum. Length of wire from index to bottom of weight is 56.30 feet. The observer is S. P. Power, jr.

The following discharge measurements were made during 1897 by Max Hall and others:

May 27, gage height, 2.10 feet; discharge, 596 second-feet.
June 22, gage height, 1.92 feet; discharge, 580 second-feet.
July 28, gage height, 2.24 feet; discharge, 920 second-feet.
August 17, gage height, 2.25 feet; discharge, 865 second-feet.
September 27, gage height, 1.60 feet; discharge, 358 second-feet.
October 29, gage height, 1.67 feet; discharge, 407 second-feet.
November 10, gage height, 1.70 feet; discharge, 395 second-feet.
December 10, gage height, 2.00 feet; discharge, 615 second-feet.

September 28, a measurement of Broad River, below mouth of South Fork, from a boat, gave a discharge of 472 second-feet. On same date a measurement of South Fork, just above mouth, gave a discharge of 150 second-feet.

Daily gage height, in feet, of Broad River at Carlton, Georgia, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	1.85	1.85	1.70	1.50	1.65	2.20	17.....	1.85	3.30	1.50	1.60	1.70	2.00
2....	1.85	1.85	2.00	1.50	2.40	2.10	18.....	3.60	2.00	1.50	1.80	1.70	2.00
3....	1.80	1.80	2.30	1.50	2.25	2.20	19.....	4.90	1.90	1.50	2.00	1.65	2.05
4....	1.80	1.80	1.85	1.50	1.95	2.70	20.....	6.30	2.00	1.50	2.40	1.65	2.10
5....	2.00	1.80	1.80	1.50	1.80	2.55	21.....	5.30	1.95	1.50	2.20	1.70	2.10
6....	2.00	1.75	1.70	1.50	1.80	2.50	22.....	3.85	2.15	1.50	2.10	1.70	2.15
7....	1.90	2.60	1.60	1.50	1.80	2.30	23.....	2.90	2.00	1.70	1.80	1.70	2.40
8....	2.10	2.20	1.55	1.50	1.75	2.10	24.....	2.30	1.95	1.70	1.80	1.70	2.20
9....	2.35	2.00	1.55	1.50	1.75	2.05	25.....	2.15	1.85	1.65	1.70	1.70	2.10
10....	2.05	2.00	1.55	1.50	1.70	2.00	26.....	2.25	1.80	1.65	1.65	1.70	2.30
11....	2.55	1.95	1.55	1.60	1.70	1.95	27.....	2.15	1.75	1.60	1.70	3.15	2.65
12....	2.35	1.90	1.55	2.45	1.70	1.95	28.....	2.30	1.75	1.60	1.65	2.75	2.30
13....	1.95	1.85	1.50	2.50	1.70	1.90	29.....	2.10	1.70	1.55	1.65	2.30	2.15
14....	1.85	1.80	1.50	2.05	1.70	2.10	30.....	1.95	1.70	1.50	1.65	2.70	2.10
15....	1.80	1.80	1.50	1.85	1.70	2.30	31.....	1.90	1.65	.....	1.65	.....	2.10
16....	1.75	4.55	1.50	1.70	1.70	2.10							

October 18–25, no readings taken; gage broken; gage heights estimated.

CAREY STATION ON OCONEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 78, is located at an iron girder deck bridge on the Georgia Railway at the station of Carey, 6 miles west of Greensboro, Georgia. It is just below the junction of the Appalachee and Oconee rivers. The observer is J. L. Carey, a farmer. The length of the wire of the gage from index to end of weight is 46.95 feet. The rod, 14 feet in length is nailed to the guard rail of the bridge on the downstream side. Its zero point is 24.8 feet from the initial point, which is the downstream end of the pier near the left bank at the end of the big iron girder. The top of the cord or iron girder 20 feet from the initial point on downstream side of bridge is 41.13 feet above datum of gage heights. Both banks are low and liable to overflow under the trestles to the end of embankments. The bed of the stream is rocky and not easily changed. The current is good. The following measurements were made by B. M. Hall and Max Hall during 1897:

January 18, gage height, 4.95 feet; discharge, 3,318 second-feet.
March 18, gage height, 5.15 feet; discharge, 4,257 second-feet.
April 29, gage height, 2.40 feet; discharge, 1,992 second-feet.
May 28, gage height, 2.10 feet; discharge, 1,047 second-feet.
June 9, gage height, 2.50 feet; discharge, 1,885 second-feet.
July 30, gage height, 1.80 feet; discharge, 1,103 second-feet.
October 4, gage height, 1.08 feet; discharge, 381 second-feet.
November 11, gage height, 1.92 feet; discharge, 678 second-feet.
December 14, gage height, 2.30 feet; discharge, 1,117 second-feet.

Daily gage height, in feet, of Oconee River at Carey, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.50	3.20	3.30	4.00	2.10	1.60	1.60	1.50	.....	2.00	2.70
2	1.90	3.80	3.20	4.90	3.80	2.10	1.50	1.50	1.20	1.50	2.20	2.40
3	2.10	3.70	3.10	6.10	3.30	2.10	1.10	1.50	1.20	1.40	2.40	2.20
4	2.00	3.60	3.90	5.60	2.80	2.20	1.10	1.50	1.40	1.10	2.00	2.60
5	2.10	3.30	3.00	8.80	2.60	2.20	1.50	1.40	1.30	1.20	1.90	2.80
6	2.00	4.60	2.90	14.40	2.50	2.30	2.70	1.90	1.20	1.40	1.80	2.70
7	2.10	5.00	6.40	12.40	2.30	2.20	2.60	2.40	.80	1.30	1.80	2.50
8	2.10	4.60	7.80	7.30	2.30	2.20	2.20	2.40	.50	1.20	1.80	2.50
9	1.80	3.80	6.80	5.40	2.30	2.50	1.60	2.20	.30	1.30	1.80	2.40
10	1.90	3.30	4.40	5.50	2.30	2.30	1.80	2.10	.30	2.90	1.90	2.30
11	2.00	3.10	4.00	4.50	2.20	2.20	1.80	2.00	.20	2.80	1.70	2.30
12	1.90	5.90	4.20	4.00	2.30	2.00	2.20	1.70	.20	2.70	1.80	2.10
13	2.00	6.60	7.70	3.50	2.30	1.80	1.70	1.50	.10	2.60	1.80	2.00
14	2.70	5.30	10.40	3.50	2.40	1.70	1.60	1.40	.30	2.30	1.70	2.30
15	4.30	4.40	12.20	3.30	2.30	1.70	1.10	1.20	.40	1.90	1.70	2.50
16	4.20	4.00	11.60	3.30	2.30	1.60	.70	1.10	.70	1.90	1.70	2.40
17	3.40	4.20	8.60	3.30	2.30	1.60	.70	2.90	1.50	1.80	1.80	2.30
18	4.50	3.60	5.50	3.00	2.20	1.60	1.80	3.10	1.40	1.60	1.90	2.10
19	4.80	3.30	4.20	2.90	2.20	1.80	3.70	3.20	1.80	1.90	1.60	2.00
20	4.00	3.00	5.30	2.80	2.20	2.40	5.60	4.10	1.50	2.10	1.80	2.00
21	6.00	3.80	5.50	2.70	2.00	2.10	5.60	3.00	1.40	2.10	1.80	2.20
22	7.80	4.00	4.60	2.70	1.90	2.00	5.80	3.70	1.40	2.00	1.80	2.30
23	6.80	3.80	4.60	2.60	2.00	1.70	5.10	2.80	1.90	2.00	1.90	2.40
24	4.30	4.70	4.70	2.60	2.20	1.50	3.10	2.60	1.80	2.10	1.80	2.40
25	3.30	5.30	4.20	2.70	2.10	2.20	2.40	2.10	1.80	2.00	1.80	2.40
26	3.10	5.20	3.70	2.50	2.10	2.00	2.40	1.80	1.70	2.00	1.70	2.40
27	2.80	4.20	3.20	2.50	2.10	1.80	2.60	1.70	1.70	1.80	2.80	2.50
28	2.80	3.50	3.20	2.50	2.00	1.60	2.30	1.60	1.70	1.80	3.50	2.60
29	2.60	.....	3.00	2.50	2.10	1.50	2.30	1.40	1.70	1.60	2.70	2.30
30	2.40	.....	3.00	2.90	2.10	1.60	1.80	1.40	1.70	1.60	2.70	2.40
31	2.50	.....	3.40	.....	2.20	.....	1.60	1.20	.....	1.80	.....	2.30

DUBLIN STATION ON OCONEE RIVER.

This station is located one-half mile east of Dublin, Georgia. The gage is vertical and is fastened to the lower side of the middle pier of the railroad bridge. Observations are taken under the direction of the Weather Bureau. The section is very good, although broken by three piers and some drift. The bed of the river is soft. The channel is straight for some distance above and below the section. The initial point for soundings is the end of iron bridge on right bank of river. The following discharge measurements were made in 1897 by B. M. Hall and P. A. Dallis:

May 5, gage height, 6.10 feet; discharge, 6,400 second-feet.
June 7, gage height, 1.90 feet; discharge, 2,861 second-feet.
June 8, gage height, 1.77 feet; discharge, 2,680 second-feet.
June 9, gage height, 1.50 feet; discharge, 2,488 second-feet.
June 10, gage height, 1.43 feet; discharge, 2,488 second-feet.
November 7, gage height, 0.40 foot; discharge, 1,644 second-feet.

Daily gage height, in feet, of Oconee River at Dublin, Georgia, from January to April, 1897.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1	2.1	2.7	12.8	8.1	17	4.8	16.0	22.7	7.2
2	2.1	3.2	13.5	10.8	18	5.0	14.6	21.4	6.8
3	2.1	5.4	13.3	12.0	19	4.6	13.1	20.0	6.4
4	2.0	6.2	9.5	14.0	20	5.2	11.7	18.0	6.6
5	2.0	6.2	7.5	15.5	21	6.0	10.2	16.0	6.4
6	1.9	6.9	7.0	15.6	22	6.0	9.2	14.7	5.0
7	1.9	8.0	7.2	15.0	23	7.2	7.6	15.5	4.5
8	1.8	8.7	8.1	14.8	24	7.8	7.5	16.2	4.4
9	1.8	9.2	8.8	16.0	25	8.4	7.8	17.0	4.3
10	1.8	9.8	9.6	16.7	26	8.4	9.9	17.7	4.1
11	1.8	9.7	10.0	16.1	27	6.4	10.5	17.0	4.0
12	1.7	10.8	10.8	14.8	28	5.2	12.0	15.5	4.0
13	1.5	11.6	11.0	13.5	29	3.8	.....	13.4	3.9
14	1.5	13.0	13.0	12.1	30	3.0	.....	10.8	4.2
15	1.5	14.3	15.5	9.9	31	2.8	.....	8.5	.....
16	1.6	16.1	20.5	8.0					

ALMON STATION ON YELLOW RIVER.

This station is located one-quarter mile east of Almon, Georgia, and 3 miles west of Covington, Georgia. It is at the low wagon bridge crossing the stream 600 feet below the Georgia Railroad bridge. The observer is A. A. Almond. The following are the discharge measurements, made by B. M. Hall and Max Hall in 1897:

September 19, 1896, gage height, 0.75 foot; discharge, 62 second-feet.
March 27, 1897, gage height, 3.90 feet; discharge, 876 second-feet.
June 21, gage height, 2.50 feet; discharge, 287 second-feet.
September 7, gage height, 1.53 feet; discharge, 123 second-feet.
December 8, gage height, 2.10 feet; discharge, 227 second-feet.

Daily gage height, in feet, of Yellow River at Almon, Georgia, from September to December, 1897.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.20	1.60	2.20	17	1.25	1.50	1.68	2.00
2	.....	1.10	1.65	2.80	18	1.30	1.60	1.69	2.08
3	.....	1.15	1.98	2.70	19	1.30	1.70	1.65	1.98
4	.....	1.20	1.90	2.20	20	1.22	1.80	1.64	2.00
5	.....	1.10	1.88	2.80	21	1.20	1.70	1.68	2.08
6	.....	1.15	1.70	2.90	22	1.20	1.68	1.67	2.09
7	.....	1.10	1.50	2.10	23	1.28	1.66	1.66	2.20
8	.....	1.10	1.60	2.08	24	1.35	1.60	1.70	2.18
9	.....	1.15	1.75	2.06	25	1.25	1.58	1.68	2.10
10	.....	1.20	1.70	2.00	26	1.30	1.50	1.70	2.18
11	.....	1.35	1.68	.....	27	1.35	1.40	1.70	2.10
12	1.40	1.90	1.66	1.98	28	1.30	1.40	1.76	2.00
13	1.30	1.98	1.64	1.95	29	1.28	1.45	1.80	1.98
14	1.42	1.90	1.64	1.89	30	1.24	1.50	2.00	2.00
15	1.40	1.80	1.64	1.86	31	.....	1.50	.....	2.04
16	1.30	1.52	1.64	1.90					

MACON STATION ON OCMULGEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 79, is at Macon, Georgia. The wire gage on the Macon, Dublin and Savannah Railroad bridge having been twice stolen in the spring of 1897, observations were taken on the Weather Bureau gage referred to the same datum, which is a vertical rod bolted to stone pier of the Georgia Railroad bridge. The observer is W. T. Bass. A bench mark on the top and upper end of the triangular casting at the foot of the seventh tie rod of the first span from the south of the former bridge is 28.84 feet above datum of gage. Measurements of discharge are made from the wagon bridge a short distance above. The velocity of the water is gentle, but not too slow for accurate measurements. The section is broken by one pier. The following measurements were made by B. M. Hall and Max Hall during 1897:

March 15, gage height, 16.75 feet; discharge, 25,535 second-feet.
May 4, gage height, 4.30 feet; discharge, 2,750 second-feet.
May 5, gage height, 3.50 feet; discharge, 2,275 second-feet.
May 18, gage height, 2.10 feet; discharge, 1,592 second-feet.
June 11, gage height, 2.85 feet; discharge, 2,111 second-feet.
June 12, gage height, 1.85 feet; discharge, 1,479 second-feet.
June 29, gage height, 0.90 foot; discharge, 1,005 second-feet.
September 23, gage height, —0.35 foot; discharge, 504 second-feet.
September 23, gage height, —0.35 foot; discharge, 497 second-feet.
November 7, gage height, 0.06 foot; discharge, 735 second-feet.
December 6, gage height, 1.20 feet; discharge, 1,356 second-feet.

Daily gage height, in feet, of Ocmulgee River at Macon, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.68	2.00	4.00	5.57	1.95	1.22	1.08	1.08	1.10	—0.50	—0.12	1.22
2	.63	5.00	3.70	9.75	1.90	1.18	.75	.84	1.25	— .45	+ .35	.70
3	.60	8.00	3.20	10.05	1.87	3.15	.65	.72	.68	— .50	.48	.60
4	.58	6.00	2.00	10.00	2.15	3.20	2.15	.40	.62	— .54	.35	.62
5	.56	6.00	4.00	15.12	2.23	3.12	2.30	.38	.35	— .61	.25	1.48
6	.54	8.00	3.00	15.15	2.47	3.10	3.80	.42	.28	— .68	.12	1.30
7	.52	6.50	11.60	12.60	3.00	3.00	3.12	1.40	.22	— .52	.10	1.12
8	.50	5.00	12.70	10.48	3.00	2.54	1.62	3.22	.12	— .55	.50	1.48
9	.49	4.75	7.50	10.00	2.91	2.32	1.28	1.10	— .07	— .55	.20	.60
10	.49	4.55	5.00	10.80	2.72	2.26	.90	.80	— .03	— .58	.20	.52
11	.51	5.00	4.80	7.80	2.57	2.18	3.10	1.60	— .10	+ .12	.30	.48
12	.49	13.50	6.00	6.40	2.45	2.08	3.33	2.00	— .50	.10	.60	.43
13	.48	12.75	17.30	5.00	3.05	2.04	1.50	1.02	— .20	.12	.30	.41
14	.53	7.00	18.00	4.70	3.15	2.01	.90	.70	— .12	.80	— .20	.90
15	.46	5.00	17.70	4.00	3.28	1.89	.30	.40	— .20	.30	— .10	1.46
16	.44	5.00	13.00	4.00	3.00	1.73	.50	.32	— .18	.10	— .18	1.22
17	.44	5.12	9.45	3.70	2.50	1.52	.22	.20	— .22	— .20	— .10	.40
18	1.15	3.00	8.25	3.50	2.22	1.45	.40	2.60	— .33	— .18	— .20	.58
19	1.50	2.75	8.20	3.20	2.09	1.37	1.48	2.28	1.60	— .20	— .20	.52
20	2.10	2.62	9.57	3.00	1.84	3.25	4.50	8.18	.20	— .02	— .10	.47
21	1.25	2.65	10.00	2.90	1.81	3.12	9.82	8.80	— .12	.00	— .08	.47
22	7.00	2.71	9.00	2.80	1.78	2.80	8.40	8.10	— .14	.20	— .13	.51
23	5.50	2.00	15.50	2.70	1.71	2.62	5.52	6.48	— .35	.18	— .10	.70
24	3.00	1.90	14.00	2.60	1.68	2.70	3.05	4.70	— .28	.10	— .50	.68
25	2.25	6.00	10.60	2.40	1.60	3.00	1.70	2.10	— .30	.05	— .20	1.02
26	2.00	10.50	8.35	2.30	1.56	3.11	1.11	1.40	— .28	.02	— .10	.89
27	3.00	7.02	7.10	2.22	1.53	2.50	1.32	1.08	— .25	— .12	+ .10	.89
28	3.12	5.00	6.40	2.16	1.50	1.00	3.22	.80	— .32	— .16	.25	1.42
29	1.50	.....	5.57	2.08	1.47	.90	2.10	.58	— .35	— .20	3.10	1.08
30	1.25	.....	5.21	2.00	1.36	1.50	1.76	.52	— .42	— .20	1.40	.75
31	1.20	.....	5.20	.....	1.28	.....	1.12	.40	.....	— .20	.....	.65

MOLENA STATION ON FLINT RIVER.

This station is located at the bridge of the Georgia Midland Division of the Southern Railway 2 miles southwest of Molena, Georgia. The wire gage is attached to the stringer of the bridge. The bench mark is the top of the dowstream iron girder under the cross-ties, 90 feet from the end of the bridge on the left side of the river, and its elevation is 30.65 above the gage datum. The channel is straight for so ne distance above and below the bridge. The right bank is low and liable to overflow, with a long trestle approach to the bridge. The left bank is not so liable to overflow, and on that side the trestle approach is shorter. The current is sluggish. There is one pier in mid-channel, but the section is better at the railroad bridge than at the wagon bridge below. The observer is J. A. Moore. The following measurements were made in 1897 by B. M. Hall and others:

May 21, gage height, 1.50 feet; discharge, 641 second-feet.
June 7, gage height, 1.75 feet; discharge, 707 second-feet.
June 23, gage height, 1.70 feet; discharge, 697 second-feet.
August 25, gage height, 3.30 feet; discharge, 2,843 second-feet.
November 8, gage height, 1.70 feet; discharge, 264 second-feet.
December 7, gage height, 2.10 feet; discharge, 588 second-feet.

At Woodbury, 3 miles below station:

May 21, gage height, 1.50 feet; discharge, 642 second-feet.

Daily gage height, in feet, of Flint River at Molena, Georgia, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.40	1.45	1.90	1.15	1.60	2.15
2	.....	1.30	1.25	1.70	1.15	1.65	2.10
3	.....	1.20	1.15	1.40	1.20	1.75	1.95
4	.....	1.35	1.10	1.25	1.20	1.70	1.95
5	.....	2.65	1.05	1.15	1.15	1.70	2.15
6	.....	2.45	1.00	1.10	1.20	1.80	2.15
7	1.75	2.25	1.25	1.05	1.25	1.70	2.10
8	2.00	1.90	1.15	1.05	1.30	1.70	2.05
9	2.00	1.75	1.10	1.00	1.30	1.65	1.95
10	1.75	1.80	1.20	1.05	1.40	1.90	1.90
11	1.30	4.05	1.50	1.00	1.45	1.90	1.90
12	1.15	3.05	1.70	1.05	1.50	1.95	1.90
13	1.50	2.55	1.55	.95	1.50	1.85	1.90
14	1.60	2.05	1.45	1.00	1.75	1.80	2.00
15	1.60	1.50	1.35	1.10	1.70	1.75	2.10
16	2.00	1.35	1.25	1.15	1.70	1.80	2.10
17	1.60	1.25	1.20	1.10	1.60	1.90	2.00
18	1.50	1.20	1.70	1.20	1.50	1.95	2.00
19	1.40	1.15	2.25	1.10	1.35	1.85	1.95
20	1.70	2.25	2.80	1.00	1.50	1.70	1.90
21	2.20	2.80	2.80	1.05	1.50	1.75	1.90
22	2.40	3.55	3.45	1.10	1.45	1.80	2.00
23	1.70	2.55	3.70	1.05	1.50	1.90	2.10
24	2.25	2.15	3.60	1.00	1.50	1.90	2.10
25	1.70	1.80	3.05	1.10	1.45	1.90	2.00
26	1.45	1.55	2.20	1.15	1.45	1.80	2.00
27	1.35	1.65	1.65	1.05	1.40	1.80	2.10
28	1.25	2.25	1.50	1.10	1.45	1.95	2.10
29	1.20	2.10	1.40	1.05	1.50	2.10	2.10
30	1.10	2.05	1.30	1.10	1.70	2.20	2.00
31	.....	1.95	3.00	.....	1.55	.....	2.00

OAKDALE STATION ON CHATTAHOOCHEE RIVER.

This station described in the Eighteenth Annual Report, Part IV, page 85, is located at the Southern Railroad bridge, 1 mile above the mouth of Proctor Creek, at Oakdale, Georgia. The pulley and rod of the wire gage is attached to the lower guard rail on the second panel of the second span from the east. The length of the wire gage is 58.85 feet. The distance from the pulley to the zero of the rod is 2.20 feet. Bench mark 1, a railroad spike in corner of stone pier, toward river, downstream side, is 12.39 feet above datum. Bench mark 2, center of pulley, is 56.36 feet above datum. The observer is J. H. Lowry. The following discharge measurements were made by B. M. Hall and others during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 24...	2.90	3,065	June 16 ...	0.94	1,523	Sept. 17 ..	—0.30	778
Apr. 27...	2.70	2,703	June 28 ...	.57	1,306	Oct. 2	— .50	659
May 22...	1.65	2,055	July 20....	12.9	15,617	Nov. 5....	.46	1,194
May 25...	1.50	2,014	Aug. 5.....	.84	1,276	Nov. 24...	— .05	879
May 31...	1.35	1,929	Aug. 27....	.33	1,196	Dec. 6....	2.65	2,426
May 31...	1.35	2,003	Sept. 10 ...	— .12	849	Dec. 28...	1.70	1,926
June 9 ...	1.44	1,991						

Daily gage height, in feet, of Chattahoochee River at Oakdale, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.20	3.10	2.00	2.90	4.10	1.00	0.50	0.85	0.50	—0.50	0.00	1.10
2	.20	4.50	1.80	4.30	3.20	1.00	.45	.80	.35	— .50	.35	.85
3	.20	4.90	1.80	5.55	2.80	1.15	.55	.90	.10	— .50	.35	1.20
4	.30	3.25	2.00	8.00	2.50	1.35	.55	.80	.20	— .45	.95	1.90
5	.40	3.70	1.90	11.80	2.40	1.15	1.15	.70	.10	— .50	.35	2.65
6	.40	4.10	2.00	17.25	2.25	1.05	.65	.65	.00	— .50	.30	2.60
7	.35	5.50	2.20	8.75	2.15	1.00	2.50	1.60	.00	— .50	.15	1.50
8	.35	5.00	5.50	5.70	2.05	.85	1.80	1.35	—.05	— .40	.15	1.10
9	.30	3.10	4.45	6.12	2.00	1.10	1.32	1.40	—.15	— .45	.10	.75
10	.30	2.40	4.05	5.30	1.95	1.00	2.45	1.20	—.15	— .45	.15	.60
11	.20	3.40	3.60	4.50	1.90	1.00	2.45	.95	—.20	+1.35	.10	.55
12	.20	4.00	6.40	4.05	1.90	.85	1.60	.80	—.20	1.50	.05	.50
13	.40	5.30	12.60	4.00	1.85	.75	1.20	.65	—.15	1.40	.00	.50
14	3.00	4.00	10.00	4.55	1.90	.65	.85	.50	—.20	— .35	—.05	1.75
15	3.70	2.60	8.40	4.05	2.35	.55	.60	.45	—.25	+ .15	—.10	1.80
16	2.80	2.60	6.80	4.00	1.85	.50	.50	.40	—.25	.00	—.05	1.90
17	2.40	2.40	5.45	3.50	1.70	1.55	4.20	2.90	—.30	— .05	+.10	1.65
18	4.00	2.10	6.10	2.20	1.50	1.00	2.45	1.25	—.30	— .15	—.05	1.15
19	4.60	1.90	5.80	3.05	1.45	1.05	12.00	.95	—.30	— .15	—.05	.65
20	5.50	2.50	5.55	3.00	1.35	.55	13.25	.65	—.35	.00	—.05	.75
21	7.50	2.50	5.00	2.80	1.85	1.35	10.30	.55	—.35	1.45	—.05	.95
22	6.85	2.90	4.30	2.75	1.40	.75	6.10	1.15	—.35	.85	—.05	1.95
23	3.90	5.10	4.50	2.70	1.40	.55	4.35	1.10	—.35	.15	—.05	2.95
24	3.20	4.50	4.00	2.70	1.35	.45	2.20	1.00	—.30	.00	—.10	1.75
25	2.00	3.60	3.90	2.65	1.30	.90	1.65	.60	—.25	.05	—.10	1.70
26	1.65	2.90	3.35	2.60	1.20	.55	2.85	.50	—.30	.05	—.10	2.25
27	.45	2.40	3.10	2.40	1.10	.45	2.30	.25	—.35	— .05	+.50	1.95
28	1.10	2.05	3.00	2.10	1.05	.30	1.35	.20	—.35	— .05	1.35	1.85
29	1.25	.....	2.75	2.00	1.00	1.00	1.20	.20	—.35	— .05	1.85	1.35
30	1.50	.....	2.70	2.20	1.05	.75	1.10	.15	—.40	— .10	1.50	2.05
31	2.00	.....	2.15	.....	1.10	.....	.95	1.65	.....	— .10	.....	.95

WEST POINT STATION ON CHATTAHOOCHEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 90, is at the highway bridge in the city of West Point, Georgia, about 1,200 feet from the railroad passenger depot. The rod on the highway bridge is nailed to the floor of the downstream footway on the outside of the iron hand rail. The center of the 3-inch pulley is at gage height 25.38 feet and 7.9 feet from zero point of rod. The length of cable from bottom of weight to index is 33.46 feet. One bench mark on the highway bridge is the top of the first-floor beam from west end pier and is 24.01 feet above zero; the other is on the top of the second-floor beam from west end pier and is 24.19 feet above zero. The bottom is sandy and liable to change. The banks of the river at the ends of the bridge seldom, if ever, overflow, but the ground between the banks and the depot is lower and does overflow at high water. The observer is C. E. Melton. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Jan. 23	6.66	11,921	June 19	2.59	2,934	Sept. 22	1.20	985
Apr. 26	3.70	5,448	July 8	3.03	3,470	Nov. 9	1.71	1,345
May 4	4.13	6,230	July 23	5.01	7,853	Nov. 23	1.60	1,322
May 19	3.00	3,557	Aug. 14	2.12	1,915	Dec. 17	3.14	3,989
June 5	2.90	3,253	Sept. 4	1.80	1,690			

Daily gage height, in feet, of Chattahoochee River at West Point, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	3.15	3.65	4.00	3.90	2.65	1.90	2.90	1.80	1.10	1.30	2.50
2	1.90	4.40	3.60	4.00	4.00	2.70	1.90	3.00	1.70	1.10	1.30	2.50
3	1.90	7.00	3.50	3.95	3.80	2.80	2.00	3.20	1.65	1.05	1.30	2.50
4	1.95	7.40	3.50	4.40	3.75	2.85	2.30	2.80	1.65	1.05	1.50	2.40
5	2.00	7.10	3.60	8.50	3.65	2.90	3.00	2.80	1.60	1.00	2.30	2.60
6	2.00	6.00	4.10	10.20	3.60	2.95	3.50	2.50	1.60	1.00	2.00	2.75
7	2.00	6.00	10.95	11.00	3.60	2.80	2.50	2.40	1.50	1.00	1.80	2.85
8	1.95	5.20	9.30	10.50	3.60	2.70	3.00	2.20	1.50	0.95	1.65	2.60
9	1.95	5.00	7.10	8.00	3.55	2.60	3.00	2.00	1.40	0.95	1.70	2.60
10	1.90	4.70	5.50	7.10	3.50	2.60	2.90	1.90	1.40	0.95	1.90	2.50
11	1.90	4.90	5.30	6.50	3.50	2.65	2.90	2.90	1.40	1.15	1.90	2.40
12	1.95	7.12	6.20	6.30	3.55	2.65	2.80	3.00	1.35	1.50	1.70	2.40
13	1.95	6.50	10.70	6.00	3.75	2.60	2.40	2.70	1.35	3.00	1.70	2.50
14	2.10	6.10	14.10	5.80	3.60	2.50	2.20	2.30	1.30	2.90	1.60	4.30
15	2.20	4.70	12.90	5.70	3.40	2.45	2.00	2.25	1.30	2.50	1.60	3.75
16	4.00	4.65	11.00	5.50	3.20	2.40	1.80	2.00	1.30	1.90	1.60	3.50
17	4.05	4.60	10.90	5.30	3.10	2.50	1.90	2.95	1.25	1.75	1.50	3.10
18	3.35	4.50	10.00	5.00	3.00	2.90	2.90	3.50	1.25	1.65	1.50	3.05
19	3.30	4.30	9.00	4.50	3.00	2.70	3.00	4.00	1.20	1.60	1.55	3.10
20	5.40	4.35	8.50	4.20	2.90	2.60	9.00	4.50	1.20	1.40	1.40	3.90
21	8.20	4.35	8.30	4.20	2.85	2.55	11.40	6.20	1.20	1.50	1.30	4.00
22	7.30	4.40	8.10	4.10	2.80	2.55	8.00	8.10	1.20	1.60	1.20	3.80
23	6.50	4.85	8.00	4.00	2.75	2.50	5.40	7.00	1.20	1.40	1.10	3.70
24	4.80	5.60	8.50	3.80	2.70	2.50	4.40	6.10	1.20	1.40	1.05	3.70
25	3.70	5.50	7.60	3.85	2.70	2.50	4.20	3.50	1.15	1.30	1.05	3.65
26	3.50	4.00	5.00	3.70	2.70	2.60	4.10	2.80	1.15	1.30	1.10	3.60
27	3.20	3.90	4.95	3.65	2.70	2.30	4.00	2.40	1.15	1.20	1.90	3.50
28	3.00	3.80	4.70	3.60	2.65	2.15	3.60	2.10	1.10	1.20	2.65	3.20
29	3.00	.....	4.50	3.60	2.65	2.00	3.50	2.10	1.10	1.40	2.60	2.80
30	2.95	.....	4.30	3.80	2.65	1.90	3.00	1.90	1.10	1.40	2.50	2.60
31	3.20	.....	4.00	.....	2.65	.....	2.80	1.90	.....	1.30	.....	2.50

CANTON STATION ON ETOWAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 94, is one-half mile above the mouth of Canton Creek, and is located at the iron highway bridge over Etowah River about 1,000 feet north of and upstream from the Atlanta, Knoxville and Northern Railroad depot at Canton, Georgia. The United States Weather Bureau gage rod is used. The observer is J. A. Low. The bench mark is on the left-bank pier. The iron bridge rests on four pieces of railroad track iron, forming a cap. Measuring from the end toward the river on one of these on the upstream side of the bridge, its top is 23.3 feet above the datum of the gage. Up to 3 feet gage height the river is only 116 feet wide, and flows between the piers on its lower banks. Up to about 14 feet it is confined between its upper banks, which are the abutments at outer end of approaches. Above this stage it begins to overflow the bottom lands. The initial point is the top of right-bank pier, at its edge toward the river. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

March 17, gage height, 2.60 feet; discharge, 2,656 second-feet.
May 5, gage height, 0.75 foot; discharge, 1,264 second-feet.
June 16, gage height, 1.27 feet; discharge, 1,632 second-feet.
August 28, gage height, —0.30 foot; discharge, 449 second-feet.
September 21, gage height, —0.60 foot; discharge, 284 second-feet.
November 12, gage height, 0.23 foot; discharge, 346 second-feet.
December 13, gage height, 0.33 foot; discharge, 514 second-feet.

Daily gage height, in feet, of Etowah River at Canton, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	—0.10	0.60	0.80	1.60	2.00	0.10	0.00	0.20	0.80	—0.70	0.20	0.60
2	— .10	2.20	.60	2.00	1.80	.10	.00	.00	.00	— .70	.80	.60
3	— .10	1.00	.60	2.00	1.80	.70	.00	.00	—.30	— .70	.80	.60
4	— .10	.80	.60	2.60	1.60	.50	.00	.00	—.40	— .50	.60	.60
5	— .10	.80	0.60	11.20	.70	.50	.00	.00	—.40	— .40	.50	2.00
6	— .10	.90	3.60	5.00	.70	.50	.00	.60	—.50	— .30	.50	1.00
7	— .10	.80	4.00	3.00	.70	.40	.40	.80	—.50	— .30	.30	.90
8	— .10	.80	2.00	2.00	.60	.40	.40	.80	—.50	— .40	.30	.80
9	— .10	.80	1.80	3.00	.60	.30	.40	.60	—.60	— .40	.30	.80
10	— .10	.80	1.80	2.60	.50	.30	.30	.60	—.60	— .40	.20	.80
11	— .10	.80	1.80	2.40	.50	.20	.30	.60	—.60	+1.20	.20	.80
12	— .10	.80	2.80	2.20	.50	.10	.20	.40	—.60	1.00	.20	.60
13	— .10	1.80	7.20	2.00	.50	.10	.20	.40	—.60	.80	.20	.80
14	2.20	1.00	6.80	2.00	.40	.10	.20	.20	—.60	.80	.20	.90
15	1.80	.80	4.00	2.00	.40	.00	.10	.20	—.60	.60	.20	.90
16	.90	.80	3.60	1.80	.40	3.00	.10	.20	—.60	.60	.20	.80
17	.50	.70	2.60	1.80	.40	1.00	.90	1.00	—.60	.60	.20	.70
18	2.00	.60	2.40	1.40	.40	.80	.90	1.00	—.60	.40	.20	.70
19	1.60	.60	2.00	1.40	.40	.60	1.00	.80	—.60	.40	.10	.80
20	3.60	.60	2.80	1.20	.40	.40	2.00	.60	—.60	.60	.10	.80
21	3.00	.80	2.00	1.20	.30	.40	7.10	.40	—.60	.40	.20	.90
22	2.00	.80	1.00	h.00	.30	.30	2.50	.20	—.60	.40	.20	1.00
23	1.00	1.60	1.80	1.00	.20	.30	1.00	.00	—.50	.40	.20	.90
24	.80	1.00	1.80	1.00	.10	.30	.80	.00	—.50	.40	.20	.80
25	.70	1.00	1.60	1.00	.10	.30	.80	.00	—.50	.40	.80	.80
26	.70	.80	1.60	.80	.10	.20	.60	— .10	—.80	.40	.60	.80
27	.70	.80	1.40	.80	.10	.10	.60	— .20	—.60	.30	.60	.70
28	.60	.80	1.20	.80	.10	.10	.50	— .30	—.50	.30	.60	.60
29	.60	.....	1.20	1.00	.10	.10	.50	— .40	—.60	.30	.80	.60
30	.60	.....	1.20	1.00	.10	.10	.40	— .40	—.60	.30	.60	.60
31	.60	.....	1.20	.....	.10	.....	.20	+1.00	.....	.20	.....	.50

CARTERS STATION ON COOSAWATTEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 96, is at the iron highway bridge at Carters, Murray County, Georgia, about 20 miles northeast of Calhoun, the most convenient railroad station. The current is not uniform, being broken by a gravel bar above, but is a fairly good section for measurement. The bed is gravel and not apt to change. The banks are high, but are sometimes overflowed. The rod of the gage is nailed to the outside of the guard timber on downstream side of the bridge. Center of 3-inch pulley is 20 feet from initial point and is 32.05 feet above datum. The zero point of rod is 5 feet from center of pulley. The length of wire cable from bottom of weight to index marker is 37.24 feet. The top of the cylindrical iron pier at the right-bank downstream corner of bridge is 30.35 feet above gage datum. The observer is Col. S. M. Carter. The following measurements were made by Max Hall and others during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.feet.*		*Feet.*	*Sec.feet.*		*Feet.*	*Sec.feet.*
May 22...	2.10	815	June28....	1.33	474	Nov. 15...	0.77	243
May 24...	1.95	771	July 15....	1.50	545	Nov. 24...	.75	263
May 26...	1.88	712	July 22....	2.41	1,079	Dec. 14...	2.71	1,118
May 28...	1.85	698	Sept. 17 ...	.70	251	Dec. 22...	3.54	1,661
June1....	1.90	724	Sept. 27 ...	.60	216			

Daily gage height, in feet, of Coosawattee River at Carters, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.40	2.05	4.05	4.00	1.90	1.40	1.35	1.00	0.60	0.80	0.75
2	1.25	4.00	1.95	4.10	3.25	1.90	1.40	1.35	1.00	.60	.80	.75
3	1.25	3.00	1.85	5.00	2.75	1.90	1.30	1.30	.95	.60	1.50	.90
4	1.25	2.15	1.85	9.00	2.50	2.20	1.30	1.30	.95	.60	1.00	2.20
5	1.20	2.40	1.80	15.00	2.40	2.00	1.30	1.40	.90	.55	.70	3.50
6	1.20	2.40	9.00	4.50	2.35	1.90	1.40	2.50	.90	.55	.60	1.90
7	1.20	2.50	5.10	4.00	2.30	1.80	1.70	2.00	.90	.55	.60	1.80
8	1.20	2.55	4.00	3.50	2.20	1.80	1.60	1.80	.80	.55	.70	1.80
9	1.15	2.55	3.50	5.50	2.15	1.70	1.60	1.60	.75	.55	.70	1.50
10	1.15	2.50	3.50	5.00	2.20	1.60	1.60	1.60	.75	.55	.80	1.50
11	1.15	2.50	3.60	4.50	2.50	1.60	1.70	1.50	.70	.55	.80	2.10
12	1.20	2.70	21.15	4.30	3.50	1.60	1.50	1.40	.70	2.50	.70	1.80
13	4.15	2.50	11.50	4.00	2.50	1.50	1.40	1.30	.70	1.10	.70	2.00
14	2.20	2.50	13.62	3.50	2.50	1.50	1.40	1.20	.70	1.00	.70	2.70
15	2.10	2.10	10.00	4.50	2.40	1.50	1.50	1.10	.70	1.00	.60	2.50
16	2.15	2.10	8.00	3.50	2.30	2.70	1.50	1.10	.65	.90	.60	2.40
17	2.20	2.05	5.50	3.30	2.30	1.80	1.50	1.10	.70	.80	.70	2.40
18	2.00	2.00	5.00	3.25	2.30	1.60	1.70	1.10	.65	.70	.70	2.60
19	2.00	2.00	6.00	3.20	2.20	1.50	9.90	1.05	.60	.70	.70	2.70
20	3.15	2.00	6.00	3.10	2.20	1.50	3.50	1.05	.60	1.45	.70	2.50
21	4.10	2.05	5.10	3.00	2.10	1.50	2.40	1.05	.60	1.40	.65	3.00
22	2.15	2.10	5.00	3.95	2.10	1.40	3.00	1.05	.60	1.10	.65	3.10
23	2.10	7.00	4.80	3.95	2.00	1.40	2.00	1.00	.60	.80	.65	2.90
24	2.00	3.50	4.50	3.90	2.00	1.50	1.50	1.00	.60	.80	.70	2.80
25	2.00	2.50	4.00	3.80	1.90	1.40	1.50	.90	.60	.70	.70	2.50
26	1.90	2.40	3.75	3.70	1.90	1.40	1.90	.90	.60	.70	.70	2.20
27	1.70	2.30	3.50	3.65	1.80	1.40	1.60	.80	.60	.60	.70	2.00
28	1.50	2.20	3.35	3.60	1.80	1.40	1.50	.80	.60	.60	.70	1.80
29	1.40	.....	3.25	3.50	1.80	2.50	1.40	.90	.60	.60	.75	1.50
30	1.30	.....	3.10	3.50	2.50	1.50	1.40	3.50	.65	.60	.75	1.40
31	1.20	.....	3.00	.....	2.00	.....	1.40	1.50	.....	.55	.....	1.30

RESACA STATION ON OOSTANAULA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 98, is at the iron railroad bridge of the Western and Atlantic Railroad, in the town of Resaca, Georgia, 1,000 feet from the depot. The river bed is probably soft and liable to change. The wire gage is adjusted to the same datum as the Weather Bureau gage at this point. The initial point is the first pin of bottom link cord at right-bank end of bridge, downstream side. The rod of the wire gage is nailed to the outside of the guard rail on the downstream side. The center of the 3 inch pulley is on the downstream side of the bridge 61.50 feet from initial point, and at 40.20 feet gage height. The end or zero point of the rod is 3 feet from the center of the pulley. The length from bottom of weight to index of gage cable is 43.40 feet. The first bench mark is on the top of capstone of center pier at 36.12 feet gage height. The second is the top of cross-tie near center at 40.12 feet gage height. The observer is S. M. Barnett, railroad agent at depot, who is also the observer for the Weather Bureau. The following discharge measurements were made by Olin P. Hall and Max Hall during 1897:

May 25, gage height, 3.48 feet; discharge, 1,535 second-feet.
May 29, gage height, 3.26 feet; discharge, 1,389 second-feet.
June 23, gage height, 2.44 feet; discharge, 972 second-feet.
September 23, gage height, 1.20 feet; discharge, 406 second-feet.
November 14, gage height, 1.46 feet; discharge, 510 second-feet.
December 24, gage height, 7.10 feet; discharge, 4,642 second-feet.
December 30, gage height, 3.42 feet; discharge, 1,630 second-feet.

Daily gage height, in feet, of Oostanaula River at Resaca, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	3.80	4.60	7.30	5.40	4.25	2.60	2.45	2.30	1.00	1.35	1.85
2	3.20	13.90	4.40	11.40	5.05	3.50	2.25	2.30	1.90	1.05	2.05	1.65
3	2.20	14.00	4.20	12.40	4.60	3.50	2.20	3.00	1.90	1.05	2.30	2.00
4	2.20	13.20	4.30	12.50	4.40	3.65	2.15	2.40	1.80	.95	2.10	4.65
5	3.00	8.70	5.90	18.50	4.25	3.35	2.20	2.50	1.80	.95	1.90	5.10
6	3.05	6.20	10.50	20.30	4.10	3.15	2.55	3.15	1.60	1.05	1.75	5.70
7	2.75	7.30	18.00	19.60	4.00	3.00	6.20	4.00	1.50	1.10	1.65	4.30
8	2.50	7.60	18.80	16.30	3.95	2.90	3.60	3.45	1.45	1.05	1.55	3.10
9	2.40	7.00	19.00	10.10	3.85	3.00	2.80	2.85	1.40	1.05	1.55	2.60
10	2.30	6.00	16.20	10.40	3.85	3.15	2.80	2.50	1.40	1.05	1.55	2.35
11	2.25	5.80	10.70	8.60	3.95	2.90	3.25	3.20	1.40	1.10	1.55	2.20
12	2.25	8.60	16.50	7.60	4.90	2.75	3.30	2.75	1.40	2.05	1.50	2.20
13	2.25	9.80	21.70	6.80	5.45	2.70	2.90	2.50	1.35	3.00	1.45	2.10
14	5.45	7.70	21.70	6.40	8.45	2.60	2.65	2.15	1.30	1.80	1.45	4.15
15	7.50	6.40	24.60	6.80	8.75	2.55	2.30	2.10	1.30	1.60	1.45	5.30
16	5.10	5.70	26.00	8.20	5.70	2.60	2.15	2.10	1.30	1.45	1.40	4.45
17	4.10	5.40	25.30	7.00	4.70	2.70	3.10	2.55	1.30	1.35	1.40	3.40
18	5.40	4.70	23.80	6.20	4.40	2.90	2.00	3.00	1.40	1.20	1.45	2.90
19	5.20	4.50	21.30	5.80	4.10	2.75	3.40	2.20	1.25	1.15	1.45	2.75
20	4.40	4.50	18.90	5.50	3.95	2.60	11.80	2.10	1.20	2.15	1.40	5.25
21	9.60	5.00	18.20	5.30	3.85	2.60	7.85	2.00	1.15	2.05	1.40	6.20
22	8.70	4.60	18.40	5.10	3.80	2.45	9.00	2.20	1.15	2.00	1.40	8.45
23	6.10	11.40	17.50	4.90	3.75	2.35	7.20	2.60	1.15	1.80	1.40	9.25
24	5.00	12.00	12.70	4.80	3.60	2.35	4.20	2.50	1.15	1.75	1.45	7.50
25	4.40	10.60	8.40	4.80	3.50	2.45	3.25	2.20	1.15	1.50	1.40	4.95
26	4.00	6.70	7.60	4.70	3.35	2.45	4.05	2.05	1.15	1.40	1.40	4.45
27	3.70	5.70	6.70	4.70	3.30	2.30	4.40	2.00	1.15	1.35	1.55	4.90
28	3.40	5.10	6.60	4.60	3.25	2.25	3.90	1.85	1.10	1.35	1.80	4.25
29	2.70	.....	6.00	4.40	3.25	3.50	3.20	1.75	1.20	1.35	1.75	3.75
30	3.10	.....	6.00	4.30	3.15	2.90	2.80	1.70	1.00	1.30	1.75	3.40
31	3.50	.....	6.00	.....	3.50	.....	2.55	1.85	.....	1.30	.....	3.20

RIVERSIDE STATION ON COOSA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 99, is at the bridge of the Southern Railway across the Coosa River near Riverside, Alabama. The observer is J. W. Foster, who is employed at a large sawmill about 300 feet distant. The center of the 3-inch pulley is 5 feet east of zero of rod, and is 33.15 feet above gage datum. The length of wire cable from bottom of weight to index is 38.35 feet. The first bench mark is the top of capstone on the large circular center pier of turn span. It is 26.80 feet above datum of gage at downstream side of pier. The top of the first iron floor beam on stationary part east of the draw, near gage, downstream end, is 31.13 feet above gage datum. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

March 31, gage height, 4.53 feet; discharge, 12,515 second-feet.
June 17, gage height, 1.54 feet; discharge, 3,747 second-feet.
July 21, gage height, 5.55 feet; discharge, 16,925 second-feet.
August 20, gage height, 2.58 feet; discharge, 6,174 second-feet.
November 29, gage height, 0.80 foot; discharge, 1,854 second-feet.

LOCK NO. 4 AND LOCK NO. 5.

The station at Lock No. 4, described in Water Supply and Irrigation Paper No. 11, page 31, is located 3 miles above Riverside, Alabama. The first section of the vertical gage rod is fastened to the lower end of the cofferdam, 500 feet below the dam on the river. The second section is fastened to a sycamore tree 150 feet below rod 1. Zero of rod is 477.30 feet above the Mobile datum. The bench mark is a brass point in stone post 1,000 feet up river from lower gage, and is 510.55 feet above Mobile datum.

The station at Lock No. 5, described in the Eighteenth Annual Report, Part IV, page 101, is located one-half mile above the Birmingham and Atlantic Railroad crossing and about 20 miles below the gaging station at Riverside, Alabama. The gage is vertical, in two sections, fastened to trees, immediately above the landing at Collin's ferry. The zero of the gage is 460.37 feet above Mobile datum. Bench mark 1 is on the oak tree, to which one section of the rod is fastened, and is 471.80 feet above Mobile datum. Bench mark 2 is center of iron plate at top of cylindrical pier at right bank, upstream side of railroad bridge below, and it is at an elevation of 493.91 feet, Mobile datum. River height observations were continued at these stations in 1897 under the direction of the United States Engineer Corps.

Daily gage height, in feet, of Coosa River at Riverside, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	2.00	5.00	4.30	3.40	1.90	1.45	2.00	1.20	0.50	0.70	0.80
2	1.10	2.50	4.50	4.45	3.10	1.90	1.45	1.80	1.10	.50	.70	.90
3	1.10	5.35	4.25	5.20	3.05	1.90	1.40	1.60	1.30	.50	.70	.95
4	1.10	7.35	3.90	7.00	3.60	1.85	1.40	1.50	1.60	.50	.65	1.20
5	1.10	7.70	4.20	8.60	3.20	1.85	1.45	1.45	1.30	.45	.80	2.50
6	1.20	7.90	5.80	9.50	3.00	1.80	1.50	1.40	1.20	.45	1.05	3.00
7	1.25	9.00	11.40	10.50	3.80	1.90	1.50	1.50	1.10	.45	1.15	2.90
8	1.30	7.70	13.30	11.15	3.70	2.15	2.40	1.50	1.00	.45	1.10	2.40
9	1.35	6.40	12.55	12.15	2.65	2.10	2.30	1.60	.90	.45	1.00	2.15
10	1.35	5.90	12.65	11.90	2.60	1.90	2.05	1.70	.85	.45	.95	2.00
11	1.35	5.20	12.70	10.70	2.50	1.90	2.50	1.70	.80	.40	.85	1.70
12	1.30	7.35	12.80	9.10	2.55	2.00	2.70	2.00	.80	.40	.85	1.60
13	1.40	8.30	13.45	7.30	2.65	1.90	2.50	2.50	.75	.45	.85	1.60
14	2.00	8.20	14.80	6.05	2.10	1.85	2.00	2.30	.75	.45	.85	2.00
15	3.50	7.50	14.60	5.60	3.90	1.60	1.80	2.00	.80	1.45	.80	2.50
16	4.00	6.60	14.80	5.30	4.00	1.70	1.70	1.80	.85	1.65	.75	3.00
17	4.90	5.70	14.70	5.60	4.00	1.50	1.80	1.60	.85	1.40	.70	3.30
18	5.35	5.00	14.70	5.40	3.60	1.60	1.95	1.50	.80	1.35	.70	3.15
19	5.00	4.50	14.50	5.00	3.20	1.90	2.00	1.90	.80	1.20	.70	2.65
20	4.80	4.00	15.80	4.60	3.00	2.00	3.00	2.60	.75	1.00	.65	2.10
21	6.50	4.60	14.90	4.30	2.70	1.80	5.20	2.00	.75	.90	.65	2.20
22	7.00	4.65	14.70	4.00	2.35	1.70	6.40	1.70	.70	.85	.65	2.80
23	7.35	6.00	14.50	3.80	2.30	1.60	8.00	1.60	.70	.80	.65	4.20
24	7.00	7.90	13.70	3.60	2.25	1.55	6.20	1.70	.70	.70	.65	4.85
25	5.40	9.00	12.20	3.40	2.25	1.50	4.50	1.75	.65	.80	.65	4.95
26	4.70	9.00	10.60	3.30	2.15	1.45	4.00	1.60	.65	.75	.65	4.55
27	3.90	8.00	8.50	3.25	2.05	1.45	3.00	1.60	.60	.60	.65	3.85
28	3.00	6.20	6.50	2.20	2.00	1.40	2.60	1.50	.55	.65	.65	3.20
29	2.70	.....	5.30	3.10	2.00	1.45	2.50	1.40	.55	.80	.70	2.95
30	2.50	.....	4.90	3.20	1.95	1.45	3.00	1.35	.55	.75	.75	2.85
31	2.20	.....	4.60	.....	1.90	.....	2.60	1.30	.....	.70	.....	2.50

Daily gage height, in feet, of Coosa River at Lock No. 4, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.8	2.0	5.8	5.1	3.4	1.9	1.1	1.9	0.8	0.1	0.3	0.4
2	.8	2.8	4.9	5.6	3.3	1.9	1.1	1.6	.7	.1	.4	.6
3	.8	6.2	4.4	7.6	3.9	1.9	1.4	1.5	.7	.1	.3	.9
4	1.0	8.8	4.4	8.2	4.6	2.1	1.3	1.3	.8	.1	.3	1.2
5	.9	9.3	5.5	9.9	3.4	2.1	1.2	1.2	1.0	.0	.3	1.6
6	.9	9.7	6.5	11.0	3.2	2.4	1.3	1.4	.8	.0	.9	2.6
7	.9	10.2	13.0	12.0	3.0	2.3	1.8	1.3	.7	— .1	.9	.....
8	1.0	9.2	14.8	12.7	2.9	2.0	2.5	1.2	.6	— .2	.8	3.7
9	1.2	7.5	15.1	13.8	2.8	1.8	2.1	1.5	.5	— .2	.7	3.1
10	1.2	6.7	14.5	13.7	2.7	1.7	2.4	2.0	.4	— .2	.6	2.4
11	1.0	6.8	14.6	12.3	2.6	1.6	2.5	2.1	.4	.0	.5	2.0
12	.9	8.6	15.0	10.0	2.6	1.7	3.0	2.1	.4	.0	.4	1.4
13	.8	9.7	15.5	8.5	3.0	1.7	2.2	2.6	.4	.0	.4	1.1
14	1.0	9.7	15.9	7.5	3.5	1.6	2.2	2.1	.4	.0	.4	1.6
15	2.3	9.0	17.0	6.7	4.5	1.5	2.2	1.8	.4	1.0	.4	1.8
16	4.3	8.0	16.8	6.4	4.5	1.4	1.6	1.5	.3	1.6	.4	2.6
17	5.7	6.6	17.0	6.4	4.7	1.3	1.6	1.3	.3	1.2	.3	3.4
18	6.2	5.0	17.0	6.2	4.5	1.4	1.9	1.5	.3	.7	.3	3.3
19	6.0	5.0	16.9	6.0	3.6	1.8	3.8	1.5	.3	.5	.3	2.8
20	5.5	4.5	17.9	5.2	3.0	2.4	5.5	2.0	.3	.4	.3	2.6
21	7.6	5.2	17.1	4.8	2.7	1.8	6.0	2.4	.2	.3	.3	2.1
22	8.2	5.8	16.9	4.0	2.5	1.5	7.5	1.6	.2	.3	.3	3.1
23	8.7	7.2	16.7	4.2	2.4	1.3	8.9	1.5	.1	.4	.3	4.8
24	8.3	9.5	15.6	4.0	2.3	1.3	7.4	1.4	.1	.4	.3	5.7
25	6.5	10.1	13.8	3.8	2.2	1.4	5.3	1.6	.1	.4	.3	5.7
26	4.8	10.2	11.8	3.6	2.2	1.2	3.9	1.6	.1	.6	.3	5.3
27	3.9	9.3	10.0	3.6	2.1	1.1	2.9	1.6	.1	.5	.3	4.4
28	3.4	7.5	7.5	3.5	1.9	1.1	2.4	1.3	.1	.4	.3	3.7
29	2.9	.....	6.3	3.4	1.9	1.3	3.0	1.1	.1	.3	.4	3.3
30	2.6	.....	5.6	3.7	1.8	1.3	2.9	1.0	.1	.3	.4	3.0
31	2.4	.....	5.2	.....	1.8	.....	2.4	.9	.....	.3	.....	2.9

Daily gage height, in feet, of Coosa River at Lock No. 5, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.2	0.9	4.6	2.9	1.7	0.7	0.3	0.8	0.2	—0.3	—0.1	—0.1
2	.2	1.2	3.6	3.2	1.6	.7	.3	.6	.1	— .3	— .1	.1
3	.2	3.1	2.2	4.5	1.9	.7	.3	.5	.1	— .3	— .1	.2
4	.2	5.2	2.9	5.2	2.0	.8	.5	.5	.4	— .3	— .1	.4
5	.2	5.8	3.1	6.8	1.9	.8	.4	.4	.4	— .3	— .1	.6
6	.2	5.8	3.7	7.6	1.5	1.0	.4	.4	.2	— .3	+ .1	1.0
7	.2	7.1	9.4	8.5	1.4	1.0	.6	.3	.1	— .3	.1	1.5
8	.3	6.0	11.1	9.0	1.3	.8	1.1	.4	.0	— .3	.1	1.5
9	.4	4.7	11.2	10.0	1.3	.7	.9	.6	.0	— .3	.1	1.4
10	.4	4.0	10.6	9.9	1.2	.6	.9	.8	— .1	— .3	.1	1.0
11	.3	3.6	10.8	8.9	1.1	.6	1.1	.9	— .1	— .3	.1	.8
12	.3	5.4	11.2	7.8	1.1	.6	1.4	.8	— .1	— .3	.1	.6
13	.2	6.4	12.2	6.6	1.3	.6	1.0	1.1	— .1	— .3	.1	.5
14	.2	6.4	12.4	4.4	1.6	.6	.9	.9	— .1	— .3	— .2	.7
15	.9	5.8	13.1	4.0	2.2	.6	.9	.7	— .1	+ .1	— .2	.8
16	.9	5.0	13.0	3.9	2.3	.5	.7	.6	— .1	.5	— .2	1.1
17	2.8	3.0	12.9	3.8	2.5	.5	.7	.5	— .1	.3	— .2	1.5
18	3.5	3.1	12.7	3.4	2.3	.5	.7	.6	— .2	.2	— .2	1.7
19	3.3	2.6	12.5	3.0	1.8	.5	1.6	.9	— .3	.1	— .2	1.2
20	3.0	2.3	13.2	2.8	1.3	1.0	3.0	1.3	— .3	— .1	— .2	.9
21	4.4	2.4	12.8	2.4	1.2	.7	3.3	1.0	— .3	— .1	— .2	.8
22	5.1	2.5	12.6	2.3	1.1	.6	4.6	.8	— .3	— .1	— .2	.8
23	5.3	4.1	12.6	2.2	1.1	.5	5.9	.6	— .3	— .1	— .2	2.4
24	5.1	6.0	11.7	2.0	1.0	.4	4.5	.5	— .3	+ .1	— .2	3.5
25	3.8	7.3	10.8	1.9	.9	.4	3.0	.5	— .3	.1	— .2	3.5
26	2.5	7.3	8.7	1.8	.9	.4	2.0	.5	— .3	.1	— .2	2.8
27	1.9	6.1	6.8	1.7	.8	.4	1.4	.5	— .3	.1	— .2	2.3
28	1.5	6.1	4.7	1.7	.7	.4	1.0	.4	— .3	.1	— .1	1.6
29	1.3	.....	3.7	1.6	.7	.4	1.3	.4	— .3	— .1	— .1	1.5
30	1.2	.....	3.3	1.7	.7	.4	1.5	.3	— .3	— .1	.....	1.4
31	1.0	.....	3.0	.....	.7	.....	1.0	.2	.....	— .1	.....	1.2

WETUMPKA STATION ON COOSA RIVER.

This station is located at gage No. 1, 3 miles above Wetumpka, Alabama. The vertical rod is in two sections of 2 by 8 timbers. Rod 1 is attached to a crib on right bank at foot of old sawmill slide. Rod 2 is attached to a tree on right bank about 150 feet upstream from rod 1. Zero of gage is 172.40 feet above mean low tide at Mobile, Alabama. The bench mark is on a black walnut tree on right bank about 250 feet upstream from gage rod No. 2; elevation, 213.88 feet, Mobile datum. It was established November 5, 1889, by the United States Engineer Corps, who have maintained daily gage readings since that date. A copy of these readings has kindly been furnished by Capt. Philip M. Price, U. S. A., and are on file in this office. The following discharge measurements were made by Charles Firth, United States assistant engineer. They were begun in December, 1890, and continued through the high water of February and March, 1891:

Measurement.	Gage height.	Discharge.	Measurement.	Gage height.	Discharge.	Measurement.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
No. 1....	2.2	8,033	No. 16...	9.5	38,116	No. 31...	18.6	73,380
2....	2.5	8,598	17...	10.0	38,414	32...	19.5	79,011
3....	3.2	10,126	18...	10.7	47,530	33...	20.0	85,549
4....	4.7	15,426	19...	10.8	43,608	34...	21.0	73,159
5....	4.9	16,569	20...	11.0	46,347	35...	21.7	85,794
6....	5.5	18,835	21...	11.2	47,923	36...	22.0	80,182
7....	6.1	21,750	22...	12.6	53,690	37...	23.0	84,688
8....	6.2	22,243	23...	13.2	52,104	38...	23.4	109,041
9....	6.6	25,198	24...	13.4	58,414	39...	25.4	93,876
10....	6.7	24,168	25...	13.8	56,357	40...	25.4	94,213
11....	7.3	26,638	26...	14.2	65,439	41...	27.0	103,255
12....	7.7	29,210	27...	15.0	56,864	42...	27.3	118,407
13....	8.2	31,620	28...	16.5	67,276	43...	28.5	126,313
14....	8.5	32,174	29...	17.2	72,907			
15....	9.2	36,722	30...	17.7	70,793			

A rating table has been made based on these measurements, but it will not be applied to the gage heights for 1896 and 1897 until it can be verified by future discharge measurements.

Daily gage height, in feet, of Coosa River at Wetumpka, Alabama, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.2	4.4	3.4	3.7	4.8	1.6	1.0	1.2	0.8	—0.1	0.4	1.2
2	3.6	4.0	3.4	4.4	4.9	1.5	.9	1.2	.6	—.2	.2	1.6
3	3.7	3.8	3.4	4.9	5.3	1.8	.8	1.2	.5	—.3	.4	2.9
4	3.6	3.6	3.2	6.1	4.1	2.2	.8	1.0	.5	2.4	.6	3.5
5	3.4	4.6	3.1	7.5	5.0	2.0	.9	1.2	.4	2.1	1.0	4.1
6	2.9	7.3	3.0	7.0	3.6	1.8	1.0	1.4	.3	2.0	1.2	3.3
7	1.5	9.8	5.0	6.5	3.6	2.2	1.3	1.4	.2	1.4	.5	2.6
8	2.8	12.2	4.9	5.8	3.3	2.0	1.6	1.3	.0	.8	.5	2.1
9	2.8	15.2	4.2	4.6	3.0	2.5	1.7	1.2	.0	.5	.4	2.0
10	2.5	15.1	4.0	4.1	2.5	3.5	4.3	1.0	.0	.2	2.2	2.0
11	2.2	14.0	4.4	3.7	2.4	3.4	5.2	.8	.0	.1	1.7	1.8
12	2.2	12.2	6.1	3.5	2.1	3.0	6.2	.8	.0	.1	1.0	1.6
13	2.4	11.7	6.9	3.3	2.0	2.5	5.9	.6	—.1	.0	4.9	1.4
14	2.6	9.9	6.7	3.3	1.8	2.0	4.4	.6	—.1	.0	2.6	1.4
15	2.2	8.7	5.2	3.1	2.9	1.6	3.8	.6	—.1	.0	2.6	1.6
16	2.6	7.4	5.8	3.0	2.3	1.6	3.0	.5	—.2	.0	2.6	1.7
17	4.0	7.2	5.0	2.9	1.8	1.6	3.7	.6	—.2	.1	3.9	1.5
18	4.0	6.9	4.8	2.7	1.5	1.5	3.6	.7	—.2	.0	4.5	1.3
19	3.8	6.7	6.4	2.4	1.5	1.5	3.0	.6	—.2	.0	3.6	1.2
20	4.0	5.6	7.3	2.4	1.5	1.8	2.7	.5	—.2	.0	3.0	1.4
21	3.9	5.0	7.8	2.4	1.5	1.5	3.4	.5	—.3	.0	2.0	1.4
22	7.6	4.5	7.5	2.3	1.5	2.0	3.1	.4	—.3	.0	1.8	1.4
23	11.6	4.2	7.2	2.2	1.5	2.0	3.4	.4	1.9	.1	1.2	1.3
24	9.7	3.4	7.0	2.0	1.5	1.8	2.7	.4	1.4	.3	1.1	1.2
25	9.4	3.4	6.3	2.1	1.4	1.5	2.1	.8	.5	.2	1.0	1.1
26	9.3	3.4	5.6	2.2	1.4	1.4	1.9	.6	.2	.1	.9	1.1
27	9.1	3.4	5.0	2.2	1.4	1.4	1.8	.5	.0	.0	.8	1.0
28	8.7	3.4	4.7	2.6	1.4	1.1	1.8	.4	.0	.0	.8	.9
29	7.6	.....	4.4	3.0	3.6	1.0	1.8	.4	—.1	.2	1.0	.9
30	6.2	.....	4.0	4.3	2.6	1.0	1.6	.4	—.1	.1	1.0	.9
31	5.2	.....	3.9	.....	1.8	.....	1.4	.6	.....	.3	.....	.8

Daily gage height, in feet, of Coosa River at Wetumpka, Alabama, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.8	2.4	6.0	5.8	4.2	1.7	0.8	1.6	1.0	0.2	0.3	0.2
2	.8	2.4	5.5	6.8	3.6	1.7	.9	1.5	.7	.2	.3	.3
3	.8	4.5	5.5	7.0	3.6	1.6	1.1	1.4	.7	.2	.4	.4
4	.9	6.9	5.2	6.8	3.6	1.6	1.8	1.4	.9	.2	.4	.8
5	.9	7.2	4.7	7.0	3.5	1.6	1.5	1.4	.8	.2	.4	1.9
6	.9	7.9	7.9	9.3	3.4	1.7	1.5	1.4	.8	.2	.4	2.0
7	.9	8.5	13.8	10.0	3.4	1.7	1.7	1.4	.8	.3	.1	2.3
8	.9	9.1	16.7	10.3	3.0	1.6	2.0	1.4	.8	.3	.1	2.5
9	1.1	7.9	18.1	11.5	2.8	1.6	2.1	1.6	.7	.3	.4	2.7
10	1.0	6.8	16.3	12.7	2.8	1.6	2.4	1.8	.7	.4	.5	2.6
11	1.0	6.3	15.7	12.3	2.6	1.5	2.2	1.9	.7	.4	.3	2.6
12	.9	9.3	14.9	10.8	2.5	1.5	2.0	2.0	.5	.4	.2	2.7
13	.9	9.0	17.8	9.0	2.5	1.4	1.8	2.0	.5	.4	.1	3.1
14	.9	9.6	21.4	7.9	2.8	1.4	1.8	2.2	.4	.4	.0	3.5
15	.9	7.3	21.9	6.7	3.0	1.2	1.8	1.8	.3	1.0	.0	3.8
16	.9	6.9	21.9	7.0	6.6	1.2	1.8	1.8	.3	1.0	.2	3.6
17	1.7	6.2	20.7	6.3	6.9	1.0	1.7	2.0	.3	1.2	.2	3.0
18	4.9	5.9	19.1	5.8	6.9	1.4	1.8	2.3	.3	1.0	.2	2.6
19	5.4	5.3	18.7	5.4	6.8	1.2	2.0	2.6	.2	.6	.3	2.5
20	5.4	5.3	17.4	5.0	6.0	1.7	2.4	2.9	.2	.4	.3	2.3
21	8.1	5.0	19.3	4.6	5.3	1.8	4.0	3.0	.2	.4	.2	2.0
22	7.3	4.7	18.4	4.5	4.6	2.0	4.8	3.6	.2	.2	.2	2.0
23	7.3	6.2	20.7	4.0	2.0	1.8	6.0	3.0	.2	.0	.3	2.4
24	7.2	7.3	19.4	4.0	2.0	1.6	7.1	2.4	.1	.0	.3	2.9
25	6.2	8.6	18.7	4.0	1.8	1.4	5.6	1.8	.1	.0	.3	4.1
26	5.6	8.6	17.5	3.8	1.8	1.2	4.6	1.4	.1	.2	.3	4.9
27	4.1	8.2	15.3	3.6	1.8	1.0	3.7	1.4	.0	.2	.3	4.6
28	3.5	7.9	10.7	3.4	1.7	1.0	2.9	1.4	.0	.4	.2	4.1
29	3.0	.....	7.0	3.4	1.7	.8	2.2	1.3	—.1	.4	.2	4.0
30	2.7	.....	6.5	3.7	1.7	.8	1.8	1.3	—.1	.3	.2	3.7
31	2.5	.....	5.5	.....	1.7	.....	1.6	1.1	.....	.3	.....	3.4

MILSTEAD STATION ON TALLAPOOSA RIVER.

This station is located on the bridge of the Tallassee and Montgomery Railroad, about one-quarter of a mile from Milstead, Alabama. The bridge is of iron, two spans of about 155 feet each, with short wood trestles at each end. The banks are high and overflow only at very high stages. The initial point for measurement is the end of iron bridge, left bank downstream side. The rod of wire gage is fastened to outside of guard rail on downstream side of bridge. Its zero is 45 feet from initial point and is 5 feet from center of pulley. The bench mark is top of second crossbeam from left bank pier, downstream end, and is 60.00 feet above datum. Center of pulley is 60.60 feet above datum. The observer is Seth Johnson.

The following discharge measurements were made during 1897 by Max Hall:

May 3, gage height, 6.20 feet; discharge, 7,333 second-feet.
July 15, gage height, 1.95 feet; discharge, 1,692 second-feet.
August 7, gage height, 2.42 feet; discharge, 2,292 second-feet.
September 4, gage height, 1.60 feet; discharge, 1,271 second-feet.
November 23, gage height, 1.20 feet; discharge, 677 second-feet.
December 16, gage height, 3.58 feet; discharge, 4,210 second-feet.

Daily gage height, in feet, of Tallapoosa River at Milstead, Alabama, from August to December, 1897.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.70	0.80	0.90	1.50	17	1.90	1.10	0.80	1.20	2.80
2	.....	1.80	.80	1.00	1.50	18	2.20	1.00	.90	1.20	2.40
3	.....	1.60	.80	1.10	1.50	19	2.80	1.10	.90	1.20	2.10
4	.....	1.60	.70	1.10	1.60	20	9.70	1.10	.90	1.10	2.00
5	.....	1.60	.70	1.10	1.80	21	7.40	1.10	.80	1.20	1.90
6	.....	1.40	.70	1.10	2.00	22	8.50	1.00	.80	1.10	2.00
7	2.45	1.40	.70	1.10	2.10	23	5.30	1.00	.90	1.10	2.40
8	1.90	1.30	.60	1.10	2.00	24	3.40	1.00	.90	1.20	2.40
9	1.70	1.20	.70	1.20	1.90	25	2.90	1.00	.80	1.20	2.40
10	1.50	1.20	.70	1.20	1.90	26	2.80	1.00	.90	1.20	2.80
11	1.50	1.10	.70	1.30	1.90	27	2.30	1.00	.90	1.20	2.60
12	2.70	1.10	.70	1.30	2.00	28	2.00	.90	.90	1.60	2.50
13	2.20	1.10	.70	1.30	1.90	29	1.80	.90	.90	1.50	2.30
14	2.00	1.10	.80	1.30	5.50	30	1.70	.80	.90	1.50	2.20
15	1.80	1.40	.80	1.20	4.70	31	1.70	.....	.90	.....	2.40
16	1.60	1.20	.80	1.20	3.60						

TUSCALOOSA STATION ON BLACK WARRIOR RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 103, is located about three-fourths of a mile from the business center of Tuscaloosa, Alabama, and is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet to the gage, which consists of an inclined timber, 2 by 6 inches, supported on posts and graduated by means of notches placed 1 foot vertically apart. The observer is W. S. Wyman, jr., Tuscaloosa, Alabama. The bench marks are fixed, one on a willow 10 feet west of gage, 97.84 feet above Mobile datum, the other on a small hackberry 30 feet south of the upper end of the gage and 139.36 feet above Mobile datum. Zero of gage is 87.30 feet above same datum. The current here is rather sluggish, being almost imperceptible at low stages. Both banks are of earth and subject to overflow. The bed of the stream is composed of sand and gravel. The following discharge measurement was made by B. M. Hall in 1897:

January 12, gage height, 1.70 feet; discharge, 829 second-feet.

Daily gage height, in feet, of Black Warrior River at Tuscaloosa, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.34	3.90	11.14	13.90	9.51	1.83	—0.15	1.36	0.60	—1.65	—1.39	—1.28
2	.47	6.00	9.57	15.28	9.95	1.75	— .18	1.08	.96	—1.71	—1.30	—1.12
3	.40	11.50	8.58	22.20	9.22	1.70	— .20	.87	1.02	—1.72	—1.29	— .48
4	.90	12.60	8.72	21.11	7.66	2.01	— .18	.62	.92	—1.75	—1.31	+1.29
5	1.24	11.70	10.14	22.00	6.23	1.98	— .05	.50	.76	—1.79	—1.33	13.10
6	1.11	12.37	16.33	26.95	5.36	2.05	1.63	.40	.62	—1.86	—1.28	14.24
7	1.40	16.24	51.42	25.32	4.67	3.44	3.40	.25	.51	—1.79	—1.27	10.72
8	2.60	18.70	54.77	22.10	4.20	2.87	3.90	.24	.47	—1.85	—1.27	7.39
9	2.66	21.04	51.59	21.30	3.87	2.25	3.71	1.10	.42	—1.88	—1.17	5.12
10	2.30	19.80	44.60	29.27	3.50	1.85	3.05	2.10	.36	—1.90	—1.13	3.72
11	2.03	17.90	40.54	29.57	3.20	1.60	2.53	3.26	.29	—1.90	—1.10	3.05
12	1.76	23.12	42.53	25.48	3.64	1.39	2.42	3.22	.23	—1.88	—1.14	2.70
13	1.52	25.90	48.70	21.60	11.40	1.24	2.16	2.73	.14	—1.89	—1.17	2.56
14	1.33	23.84	50.96	18.10	20.36	1.11	1.86	2.27	.11	—1.92	—1.25	3.05
15	1.23	20.30	48.57	16.32	20.46	.95	1.46	1.63	.10	—1.92	—1.25	3.54
16	8.23	16.96	45.20	18.43	16.59	.85	1.16	1.28	.06	—1.92	—1.27	4.12
17	9.70	14.04	47.21	18.33	12.68	.75	.97	1.00	.01	—1.90	—1.33	4.10
18	13.10	11.72	46.72	15.92	9.77	.63	1.50	.73	— .05	—1.90	—1.35	3.78
19	19.35	9.97	42.90	13.66	7.73	1.30	3.50	.52	— .36	—1.90	—1.36	3.50
20	18.70	8.77	42.57	11.86	6.35	1.45	12.50	1.53	— .75	—1.88	—1.36	3.82
21	17.43	8.08	44.54	10.45	5.37	1.11	14.50	1.78	— .95	—1.88	—1.36	6.70
22	18.64	8.32	41.50	9.24	4.66	.80	11.30	1.58	—1.07	—1.77	—1.37	19.58
23	16.52	11.00	37.70	8.15	4.13	.55	8.42	1.33	—1.17	—1.64	—1.42	31.00
24	13.30	20.20	35.66	7.37	3.70	.33	6.64	1.08	—1.26	—1.58	—1.44	29.96
25	10.60	21.24	32.40	6.80	3.45	.23	4.77	1.27	—1.24	—1.63	—1.40	24.08
26	8.60	18.97	28.86	6.37	3.13	.16	3.46	.97	—1.36	—1.63	—1.36	18.97
27	7.20	16.18	25.60	5.90	2.90	.12	2.72	.80	—1.41	—1.61	—1.36	15.67
28	6.00	13.31	23.15	5.49	2.60	.03	2.92	.61	—1.44	—1.64	—1.28	13.10
29	5.10	.....	20.33	5.10	2.28	.00	2.15	.54	—1.50	—1.61	—1.22	11.00
30	4.42	.....	17.52	5.90	2.09	— .08	1.80	.46	—1.55	—1.63	—1.24	9.38
31	3.80	.....	14.98	.....	2.00	.....	1.62	.31	.....	—1.63	.....	8.00

ALDERSON STATION ON GREENBRIER RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 111. It is located one-half mile above the mouth of Muddy Creek, on the county bridge at Alderson, West Virginia. The wire gage is in the third panel of the second span, lower side. The distance from the end of the weight to the marker is 28.37 feet. The distance from the zero of the gage to the top of the lower end of the third floor beam, second span, from the left bank, is 22.47 feet. Bench marks: Upper end of coping of the first pier from left bank 21.75 feet above the zero of the gage; upper end of the bridge seat of the left bank abutment 21.61 feet above the zero of the gage; stone foundation of the water tank of the Chesapeake and Ohio Railway 23.48 feet above the zero of the gage. The observer is W. J. Hancock, clerk in the store of George Graves. The following measurements of discharge were made by Prof. D. C. Humphreys and F. H. Anschutz in 1897:

March 30, gage height, 2.75 feet; discharge, 1,639 second-feet.
May 3, gage height, 4.88 feet; discharge, 6,181 second-feet.
May 4, gage height, 4.29 feet; discharge, 4,963 second-feet.
May 4, gage height, 4.38 feet; discharge, 5,450 second feet.
May 6, gage height, 3.56 feet; discharge, 3,158 second-feet.
May 13, gage height, 12.30 feet; discharge, 32,563 second-feet.
May 14, gage height, 12.33 feet; discharge, 33,034 second-feet.
May 14, gage height, 9.53 feet; discharge, 20,722 second-feet.
May 31, gage height, 2.26 feet; discharge, 681 second feet.
October 12, gage height, 1.42 feet; discharge, 71 second-feet.

Daily gage height, in feet, of Greenbrier River at Alderson, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.22	3.05	2.77	2.18	2.55	2.03	2.35	1.62	1.43	1.40	2.00
2	1.95	2.21	2.90	2.75	3.44	2.65	3.40	2.25	1.58	1.38	1.52	1.90
3	1.98	2.20	2.80	2.67	4.80	2.45	4.30	2.45	1.58	1.40	1.48	1.85
4	2.00	2.05	2.75	2.63	4.44	2.35	3.40	2.45	1.55	1.40	1.58	1.85
5	2.10	2.02	3.13	2.78	3.90	2.50	2.87	2.34	1.50	1.45	1.55	2.30
6	2.85	4.04	3.15	4.83	3.60	2.47	3.40	2.30	1.50	1.44	1.60	3.26
7	2.80	6.62	3.42	4.18	3.52	2.40	3.35	2.18	1.53	1.41	1.60	3.17
8	2.45	5.20	3.80	3.65	3.25	2.28	3.25	2.15	1.50	1.40	1.66	2.68
9	2.35	4.20	3.50	3.50	3.03	2.26	2.93	2.05	1.48	1.40	1.62	2.43
10	2.35	3.55	3.60	4.78	2.92	2.30	2.75	2.00	1.50	1.38	1.60	2.25
11	2.35	3.43	4.85	4.50	2.83	2.23	2.45	2.00	1.49	1.36	1.60	2.05
12	2.20	4.08	4.52	4.00	3.16	2.17	2.70	1.97	1.48	1.40	1.60	2.05
13	2.05	5.40	4.65	3.50	8.26	2.20	2.60	1.91	1.44	1.41	1.90	1.98
14	2.00	5.07	4.40	3.20	12.20	2.23	2.38	1.85	1.44	1.42	1.63	1.95
15	1.95	5.00	6.10	3.05	6.01	2.20	2.28	1.83	1.43	1.43	1.75	1.97
16	2.20	5.10	5.12	3.00	4.75	2.98	2.17	1.83	1.42	1.43	1.72	2.37
17	2.20	5.10	4.10	2.95	4.05	2.65	2.08	1.80	1.40	1.43	1.74	3.07
18	2.20	4.45	3.80	2.95	3.55	2.55	2.00	1.78	1.40	1.37	1.68	2.77
19	2.60	4.48	6.00	2.82	3.25	2.45	2.10	1.75	1.38	1.52	1.65	2.60
20	2.65	4.38	6.75	2.75	3.05	2.90	2.15	1.72	1.38	1.50	1.67	2.55
21	2.55	4.35	6.15	2.68	2.90	2.95	2.34	1.70	1.40	1.52	1.65	2.68
22	2.55	10.08	4.15	2.58	2.80	2.80	4.85	1.67	1.40	1.53	1.67	4.30
23	2.60	16.93	3.95	2.50	2.68	2.65	4.65	1.67	1.37	1.50	1.67	3.83
24	2.60	9.23	3.55	2.45	2.58	2.50	4.00	1.80	1.37	1.50	1.60	3.20
25	2.45	5.80	3.45	2.35	2.50	2.45	4.05	1.73	1.38	1.50	1.60	2.85
26	2.50	4.55	3.25	2.35	2.50	2.48	3.28	1.77	1.40	1.54	1.57	2.50
27	2.42	3.80	3.07	2.35	2.42	2.20	3.46	1.68	1.35	1.52	1.55	2.35
28	2.35	3.35	2.95	2.28	2.33	2.13	3.40	1.68	1.40	1.52	1.55	2.43
29	2.25	.....	2.88	2.25	2.28	2.05	2.65	1.70	1.40	1.52	1.78	2.25
30	2.20	.....	2.82	2.20	2.23	2.00	2.57	1.66	1.40	1.48	2.07	2.15
31	2.20	.....	2.80	.....	2.25	.....	2.48	1.64	.....	1.45	.....	2.15

FAYETTE STATION ON NEW RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 113, is located just below the mouth of Wolf Creek on a highway bridge of one span, at Fayette, West Virginia. The wire gage is located on the guard rail, on the upper side of the bridge about the middle of the span, and the graduation is to feet and tenths. Bench marks: The top of the bottom plate of the lower plate girder, at the end of the first panel from the left bank, lower side, is 55.13 feet above the zero of the gage; top of lower end of coping on the main pier, right bank, lower side, 52.13 feet above the zero of the gage; bridge seat, on the right bank, lower side, 54.58 feet above the zero of the gage; west corner of abutment stone, by Chesapeake and Ohio Railway station, 58.62 feet above the zero of the gage. The observer is M. W. Brellahan, agent Chesapeake and Ohio Railway. The following discharge measurements were made by Prof. D. C. Humphreys and F. H. Anschutz in 1897:

March 31, gage height, 5.50 feet; discharge, 9,587 second-feet.
May 5, gage height, 8.50 feet; discharge, 15,931 second-feet.
May 15, gage height, 13.98 feet; discharge, 35,195 second-feet.
May 31, gage height, 3.70 feet; discharge, 5,145 second-feet.
October 12, gage height, —0.18 foot; discharge, 1,136 second-feet.
November 5, gage height, 1.72 feet; discharge, 2,616 second-feet.

Daily gage height, in feet, of New River at Fayette, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	1.90	7.20	6.00	4.30	3.25	2.25	4.07	1.20	0.10	1.40	0.40
2	2.30	2.05	6.65	5.50	4.30	3.60	3.15	3.25	1.10	.05	1.55	.45
3	3.00	2.20	6.35	5.05	7.80	3.65	3.55	2.85	1.05	.05	1.80	1.15
4	3.30	3.05	6.05	5.90	9.52	3.50	4.52	2.40	.95	.01	1.90	1.25
5	3.60	4.30	6.15	6.95	9.25	3.33	4.50	2.50	.90	.00	1.75	1.25
6	3.20	6.50	6.50	7.10	7.48	3.30	4.10	2.90	.65	.00	2.00	1.05
7	3.50	16.72	7.25	9.80	6.50	4.70	3.73	2.80	.50	.05	2.40	1.10
8	4.00	14.10	7.40	11.10	6.20	5.00	4.75	2.75	.45	.10	1.50	3.75
9	3.50	8.60	7.70	7.80	5.25	5.95	3.80	4.60	.40	.10	1.30	3.00
10	3.35	6.03	12.05	8.10	5.15	6.55	3.50	4.05	.35	.05	1.25	2.95
11	3.00	6.40	16.00	9.75	4.75	6.22	3.45	3.00	.35	.00	1.20	1.85
12	2.90	9.20	11.70	8.50	5.95	5.25	3.85	2.50	.20	.00	1.00	1.20
13	2.35	13.70	14.00	8.00	6.12	5.00	3.50	2.25	.00	.00	.80	1.15
14	2.05	14.70	15.20	7.15	20.58	4.60	3.05	2.10	.95	5.56	.70	1.30
15	2.30	14.00	17.40	6.45	16.10	3.55	2.40	2.00	.80	2.95	.70	1.80
16	2.10	13.25	16.80	6.10	11.00	3.40	1.90	1.60	.75	1.85	.70	1.70
17	2.45	10.10	15.70	6.30	8.20	3.80	2.00	1.30	.90	1.05	.60	1.75
18	2.75	9.90	13.00	6.05	7.50	3.50	2.25	1.25	.90	.90	.55	3.50
19	3.00	9.00	14.10	5.80	6.55	3.10	2.25	1.35	.90	.70	.45	3.40
20	3.45	9.25	12.30	5.45	5.70	4.40	2.45	1.40	.50	.60	.40	3.20
21	4.00	20.10	11.40	5.15	5.35	4.85	2.90	1.80	.50	.45	.40	3.00
22	4.50	26.12	10.30	4.85	5.00	5.25	5.50	1.90	.50	.50	.35	3.40
23	4.70	27.55	9.60	4.50	4.65	5.38	8.10	1.85	.00	4.05	.20	5.25
24	4.00	23.18	9.20	4.20	4.10	3.95	11.48	1.75	.50	2.35	.10	3.85
25	3.80	18.30	8.70	4.10	4.00	3.40	10.00	1.75	.50	1.50	.15	3.10
26	2.90	11.55	8.25	4.00	3.85	3.25	9.50	1.85	.65	1.10	.25	3.10
27	2.30	8.15	7.00	3.85	3.30	3.08	8.20	1.80	.75	1.05	.00	2.40
28	1.95	7.80	6.70	3.70	3.30	2.57	7.85	1.90	.80	.95	.05	2.40
29	1.60	.....	6.65	3.60	3.90	2.38	6.70	1.90	.60	.90	.20	1.90
30	1.35	.....	6.40	3.50	3.78	2.35	5.30	1.00	.30	.80	.20	2.10
31	1.60	.....	6.25	.....	3.70	.....	4.25	1.35	.....	1.10	.....	2.00

ASHEVILLE STATION ON FRENCH BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 116, is located at the Bingham school iron highway bridge, 3 miles west of Asheville, North Carolina, and is reached by electric-car line. It is also 3 miles below the mouth of Swannanoa River. The gage is a wire one. The zero of the rod is opposite the east edge of the fifth upright, first span from east, upper side. The outside edge of the pulley is 3 feet from the end of the rod, and the length of the wire cable from the end of the weight to the index marker is 26.03 feet. When the gage height is 3.22 feet the water surface is 17.18 feet below top of the lower end of the second floor beam, first span from the east.

The initial point for soundings is on the right bank, at the end of the first span of the bridge. Both banks may overflow in very high water. The current is swift and the channel is rough and rocky, and reasonably permanent. The observer is J. M. Taylor, a carpenter of Asheville, North Carolina. The following discharge measurements were made by E. W. Myers and others during 1897:

August 18, gage height, 2.86 feet; discharge, 882 second-feet.
October 14, gage height, 2.84 feet; discharge, 808 second-feet.
October 27, gage height, 2.50 feet; discharge, 734 second-feet.

Daily gage height, in feet, of French Broad River at Asheville, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.60	3.90	4.25	7.10	3.30	3.30	2.75	2.65	2.30	2.90	2.85
2	2.75	3.80	3.80	4.20	7.00	3.25	3.15	2.80	2.63	2.30	3.85	2.85
3	2.70	4.60	3.80	4.15	3.90	3.90	3.05	2.85	2.60	2.30	3.83	2.90
4	2.90	4.90	3.80	5.30	5.70	3.95	3.10	2.95	2.60	2.27	3.77	3.00
5	3.25	4.90	3.70	7.60	4.50	3.85	3.15	2.95	2.60	2.27	2.95	3.00
6	3.25	7.90	7.00	7.30	4.30	3.40	3.25	3.10	2.55	2.25	2.85	2.90
7	2.95	7.40	7.25	6.90	4.00	3.30	3.35	4.00	2.55	2.25	2.65	2.83
8	2.93	6.40	5.50	6.50	3.90	4.50	3.37	4.00	2.53	2.23	2.55	2.77
9	2.93	4.85	5.00	5.40	3.85	3.80	3.37	3.05	2.45	2.23	2.53	2.65
10	2.87	4.55	5.10	5.35	3.80	3.65	3.25	3.03	2.40	2.23	2.50	2.63
11	2.85	4.60	5.20	4.60	3.60	3.40	3.60	3.00	2.37	3.35	2.47	2.60
12	2.85	4.70	6.20	4.55	3.45	3.30	3.40	2.80	2.37	3.30	2.46	2.60
13	2.87	4.60	6.43	4.40	4.00	3.20	3.20	2.73	2.35	3.20	2.45	2.55
14	2.90	4.55	7.00	4.60	4.15	3.15	3.25	2.70	2.35	2.83	2.45	2.45
15	2.85	4.35	5.90	4.60	4.00	3.05	3.30	2.70	2.40	2.75	2.45	2.45
16	2.83	4.15	6.40	4.50	3.70	3.30	3.30	2.80	2.40	2.65	2.45	3.15
17	2.95	3.95	5.90	4.35	3.65	3.40	3.40	2.85	2.35	2.63	2.43	3.15
18	3.35	3.90	5.30	4.15	3.65	3.55	3.35	2.87	2.33	2.45	2.43	3.10
19	3.15	3.85	5.45	4.10	3.55	3.60	3.35	2.85	2.37	3.25	2.40	2.95
20	3.50	3.75	5.85	4.05	3.53	3.35	3.25	2.92	2.35	3.23	2.37	3.00
21	4.45	4.15	5.50	4.00	3.50	3.35	3.40	2.90	2.33	2.85	2.27	3.15
22	4.40	3.90	4.90	3.90	3.50	3.25	3.55	2.90	2.40	2.75	2.35	3.20
23	3.65	6.85	4.75	3.85	3.50	3.40	3.40	2.85	2.50	2.67	2.33	3.25
24	3.55	6.05	4.65	3.85	3.50	3.55	3.35	2.83	2.45	2.65	2.35	3.20
25	3.45	4.86	4.55	3.75	3.45	3.40	3.30	2.70	2.43	2.63	2.40	3.05
26	3.35	4.35	4.45	3.70	3.35	3.35	3.15	2.70	2.43	2.50	2.60	3.25
27	3.35	4.20	4.45	3.70	3.37	3.30	3.20	2.70	2.40	2.50	2.90	3.40
28	3.45	4.15	4.35	3.67	3.27	3.50	3.10	2.65	2.37	2.47	2.85	3.65
29	3.43	.....	4.10	3.65	3.25	3.65	3.05	2.50	2.35	2.45	2.83	3.57
30	3.33	.....	4.00	5.40	3.35	3.45	3.00	2.55	2.33	2.45	2.90	3.50
31	3.45	.....	4.10	.....	3.35	.....	2.75	2.57	.....	2.45	.....	3.40

BRYSON STATION ON TUCKASEEGEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 116, was located on the Southern Railway bridge about 3 miles above Bryson, North Carolina, and just below Governor Island post-office, and was abandoned March 25 because the section was poor. A new station was established November, 1897, in the town of Bryson, at the highway bridge. The bottom is muddy, the water is deep, and the current is very sluggish. The gage is bolted to the north pier and lower side, and can be read from the bridge. The initial point for soundings is the south end, upstream hand-rail. The channel is obstructed by the remains of two old piers. The observer is H. H. Welch. The following discharge measurement was made in 1897 by A. P. Davis:

October 28, gage height, 1.00 foot; discharge, 168 second-feet.

Daily gage height, in feet, of Tuckaseegee River at Bryson, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Nov.	Dec.	Day.	Jan.	Feb.	Mar.	Nov.	Dec.
1	2.25	3.10	3.75	.....	1.25	17	2.90	3.60	5.70	1.00	1.30
2	2.20	3.80	3.60	.....	1.10	18	3.30	3.50	5.80	1.00	1.30
3	2.30	3.10	4.40	.....	1.35	19	2.90	3.50	6.90	1.00	1.60
4	2.50	3.00	3.65	.....	1.60	20	3.30	3.70	5.70	1.00	1.70
5	2.80	3.30	3.60	.....	2.30	21	3.30	4.30	5.60	1.00	3.40
6	2.40	5.52	7.50	.....	1.60	22	3.30	4.55	5.40	1.00	2.60
7	2.40	4.70	5.60	1.05	1.30	23	3.25	4.90	5.10	1.00	2.05
8	2.40	4.10	4.90	1.00	1.25	24	3.00	8.85	5.00	1.00	1.70
9	2.40	4.00	5.00	1.15	1.20	25	2.90	5.30	4.80	1.00	1.60
10	2.30	3.80	7.10	1.10	1.15	26	2.85	4.70	.....	1.00	1.70
11	2.30	4.00	5.30	1.00	1.15	27	2.80	4.30	.....	1.40	1.65
12	2.40	5.40	9.15	1.00	1.15	28	2.20	3.90	.....	1.20	1.50
13	2.30	5.00	6.80	1.00	1.30	29	2.20	.....	.....	1.30	1.45
14	3.00	4.15	7.70	1.00	2.00	30	2.60	.....	.....	1.30	1.40
15	2.80	3.90	6.20	1.00	1.70	31	2.90	.....	.....	.....	1.50
16	2.60	3.80	6.90	1.00	1.40						

JUDSON STATION ON LITTLE TENNESSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 117, is located on the Southern Railway bridge about one-fourth of a mile from Judson, North Carolina, and below the mouth of Sawyer Branch. The zero of the gage rod is 25 feet west of the east end of the second span from the east. The outer rim of the pulley wheel is 2 feet from the zero of the gage rod, and the distance from the end of the weight to the marker on the wire rope is 26.25 feet. The gage reads zero when the weight touches the bottom of the stream. The bottom is rocky and very rough on the west side of the stream, and sandy on the east side, and the current is very swift. The river is straight for several hundred yards above and below the station. The section is not a very good one, as there are two bad pier obstructions. The observer is R. C. Sawyer, Judson, North Carolina. The following discharge measurements were made by E. W. Myers and A. P. Davis in 1897:

August 21, gage height, 3.21 feet; discharge, 771 second-feet.
October 13, gage height, 2.75 feet; discharge, 701 second-feet.
October 28, gage height, 2.44 feet; discharge, 448 second-feet.

Daily gage height, in feet, of Little Tennessee River at Judson, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	5.50	4.20	6.23	4.20	3.82	3.30	3.48	2.83	2.52	2.38	2.58
2	3.56	6.40	3.56	7.50	3.56	3.78	3.50	3.46	2.85	2.53	3.30	2.56
3	3.53	5.54	3.56	7.91	3.54	2.91	3.42	3.30	2.89	2.60	2.86	2.55
4	3.54	4.80	3.53	7.90	3.52	4.20	3.50	3.43	2.86	2.54	2.70	3.00
5	3.51	4.59	3.56	6.55	3.53	4.80	3.60	3.45	2.84	2.55	2.58	4.58
6	3.52	5.30	4.50	6.53	3.58	3.90	3.70	3.40	2.84	2.57	2.79	4.39
7	3.65	4.56	4.35	5.80	3.57	3.59	3.63	3.46	2.85	2.50	2.80	4.00
8	3.65	4.59	4.59	5.70	3.57	3.58	3.67	3.48	2.73	2.56	2.72	3.80
9	3.64	4.50	6.40	5.30	3.22	3.55	3.75	3.47	2.71	2.53	2.73	3.00
10	3.63	4.47	7.29	4.23	3.23	3.56	3.72	3.44	2.73	4.54	2.78	2.90
11	3.69	5.20	7.38	4.50	3.27	3.59	3.70	3.38	2.77	4.58	2.70	2.89
12	3.65	5.28	9.20	4.60	3.27	3.57	3.48	3.35	2.89	2.56	2.76	2.86
13	3.66	5.26	7.82	5.70	4.76	3.58	3.49	3.36	2.89	2.49	2.79	2.80
14	3.65	5.30	7.23	5.23	5.21	3.53	3.42	3.32	2.83	2.50	2.61	3.51
15	3.64	4.59	7.15	4.59	5.13	3.59	3.45	3.35	2.88	2.53	2.63	3.00
16	3.62	4.56	6.35	5.40	4.12	3.61	3.51	4.00	2.86	2.53	2.68	3.00
17	3.65	3.70	5.53	4.54	4.90	3.62	4.33	3.86	2.90	2.54	2.73	2.89
18	3.64	3.80	6.95	3.53	4.70	3.60	4.56	3.86	2.90	2.60	2.70	2.90
19	3.69	3.53	7.65	3.52	4.30	3.60	4.91	3.78	2.80	2.22	2.69	2.96
20	4.80	3.52	8.90	3.15	3.57	3.48	5.20	3.52	2.38	3.48	2.67	3.40
21	4.80	4.30	8.00	3.22	3.56	3.50	4.36	3.32	2.40	3.37	2.68	3.58
22	4.82	5.60	8.50	3.21	3.56	3.42	4.20	3.22	2.37	2.86	2.60	4.56
23	4.62	8.60	7.53	3.18	3.41	3.44	4.21	3.23	2.33	2.70	2.65	4.50
24	4.60	6.75	7.85	3.18	3.90	3.47	3.78	3.35	2.39	2.72	2.67	3.48
25	3.90	4.75	6.25	3.32	3.70	3.41	3.72	3.29	2.50	2.60	2.70	3.36
26	3.84	4.63	5.55	3.39	3.90	3.48	3.70	3.90	2.60	2.63	2.82	3.38
27	3.84	4.53	5.53	3.30	3.80	3.46	3.73	3.00	2.52	2.35	3.10	3.30
28	3.83	4.29	5.60	3.41	3.51	3.45	3.71	3.33	2.50	2.39	2.89	3.00
29	3.68	.....	5.56	3.90	3.60	3.43	3.75	2.78	2.53	2.39	2.80	2.97
30	3.69	.....	5.70	3.99	3.90	3.40	3.71	2.79	2.57	2.38	2.86	2.78
31	3.65	.....	6.21	.....	3.80	.....	3.69	2.77	.....	2.34	.....	2.90

MURPHY STATION ON HIWASSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 117, is located on the highway bridge crossing the river at Murphy, North Carolina, one-half mile above Valley River. The zero of the gage rod is 8 feet north of the center of the second full-length compression member from the north end and on the downstream side of bridge. The outer rim of the pulley wheel is 2 feet from the zero of the gage rod, and the distance from the end of the weight to the marker on the wire is 29.10 feet. The reading of the gage is zero when the weight touches the bottom of the river. The section here is a fairly good one, though somewhat obstructed by the remains of two old piers directly under the present bridge. The course of the stream is straight for several hundred yards above and below the bridge and the current fairly rapid. The bottom is hard and rocky and is not subject to any decided change by high water. The banks are high and not subject to overflow except in very high water. The observer here is M. L. Brittain. The following measurements were made by E. W. Myers and A. P. Davis in 1897:

August 20, gage height, 5.33 feet; discharge, 528 second-feet.
October 14, gage height, 4.76 feet; discharge, 267 second-feet.
October 29, gage height, 4.71 feet; discharge, 253 second-feet.

Daily gage height, in feet, of Hiwassee River at Murphy, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.90	4.80	4.60	5.40	4.80	4.16	3.90	4.20	.....	.....	5.00	5.02
2	3.90	5.50	4.50	5.50	4.70	4.15	3.90	4.32	.....	.....	5.40	5.00
3	3.90	4.90	4.55	5.38	4.65	4.12	3.90	4.20	.....	.....	5.10	5.10
4	3.90	4.62	4.70	6.26	4.60	4.10	3.90	4.10	.....	.....	5.02	5.45
5	4.12	4.60	4.60	8.20	4.55	4.30	4.15	4.35	.....	.....	5.00	6.10
6	4.02	5.15	9.20	6.12	4.52	4.12	4.00	4.20	.....	.....	5.00	5.50
7	4.00	5.40	6.50	5.75	4.50	4.10	4.02	4.20	.....	.....	4.95	5.30
8	4.00	5.12	5.65	5.50	4.50	4.10	4.10	.....	.....	.....	5.00	5.20
9	3.92	5.10	5.40	6.10	4.50	4.22	4.10	.....	.....	.....	4.98	5.12
10	3.92	4.85	5.62	5.35	4.45	4.10	4.25	.....	.....	.....	5.00	5.10
11	4.00	4.85	5.50	5.30	4.52	4.02	4.15	.....	.....	.....	5.00	5.10
12	3.90	4.82	9.90	5.15	4.40	4.05	4.00	.....	.....	.....	4.95	5.10
13	3.92	4.82	6.85	5.05	5.00	4.05	3.98	.....	.....	.....	4.95	5.02
14	4.40	4.12	6.70	5.05	4.80	4.00	3.90	.....	.....	.....	5.00	6.20
15	4.60	4.70	6.12	5.50	4.60	4.00	3.85	.....	.....	.....	5.00	5.55
16	4.15	4.60	7.65	5.05	4.50	4.10	3.90	.....	.....	.....	5.00	5.30
17	4.55	.....	6.30	5.00	4.50	4.03	4.50	.....	.....	.....	4.95	5.28
18	4.40	.....	6.00	4.90	4.42	4.10	4.05	.....	.....	.....	4.95	5.20
19	4.40	.....	7.05	4.80	4.40	4.20	5.72	.....	.....	.....	4.95	5.40
20	5.10	.....	6.80	4.80	4.32	4.15	5.00	.....	.....	5.00	4.95	6.00
21	4.70	4.80	6.10	4.70	4.36	4.05	4.50	.....	.....	4.75	4.95	7.35
22	4.52	4.50	5.80	4.70	4.35	4.00	4.85	.....	.....	4.75	4.95	6.85
23	4.40	7.92	5.55	4.70	4.30	4.00	4.34	.....	.....	4.70	4.90	6.15
24	4.40	5.50	5.40	4.70	4.26	4.00	4.20	.....	.....	4.70	4.90	5.80
25	4.40	5.10	5.30	4.65	4.25	4.00	10.85	.....	.....	4.70	5.00	5.50
26	4.20	4.97	5.15	4.70	4.22	4.00	6.20	.....	.....	4.65	4.98	5.85
27	4.30	4.70	5.10	4.63	4.20	3.90	5.20	.....	.....	4.66	5.00	5.60
28	4.10	4.64	5.00	4.60	4.20	3.90	4.72	.....	.....	4.70	5.05	5.50
29	4.15	.....	4.90	4.60	4.20	4.30	4.52	.....	.....	4.72	5.00	5.40
30	4.15	.....	5.00	4.68	4.20	4.00	4.40	.....	.....	4.90	5.10	5.40
31	4.15	.....	4.90	.....	4.20	.....	4.25	.....	.....	4.87	.....	5.30

CHATTANOOGA STATION ON TENNESSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 119, is located on the Tennessee River at the city of Chattanooga, Tennessee. The gage is on an incline of railroad iron for about 20 feet in its lower portion. Above this it is a vertical rod bolted to the vertical rock bluff forming the river bank. The zero of the gage is 630.64 feet above sea level. It is located at the foot of Lookout street, just below Chattanooga Island. Measurements are made from the Hamilton County steel highway bridge at the foot of Walnut street, a short distance below the gage. The observer is L. M. Prindell. The following discharge measurements were made by Max Hall and others during 1897:

May 8, gage height, 7.07 feet; discharge, 44,187 second-feet.
May 28, gage height, 4.52 feet; discharge, 25,892 second-feet.
June 29, gage height, 5.76 feet; discharge, 32,943 second-feet.
July 13, gage height, 4.59 feet; discharge, 26,884 second-feet.
September 7, gage height, 1.67 feet; discharge, 10,313 second-feet.
October 6, gage height, 0.48 foot; discharge, 5,969 second-feet.
November 16, gage height, 0.83 foot; discharge, 5,552 second-feet.
December 23, gage height, 10.30 feet; discharge, 67,000 second-feet.

Daily gage height, in feet, of Tennessee River at Chattanooga, Tennessee, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.4	3.0	12.5	8.7	5.9	4.3	5.0	4.4	2.1	0.8	0.8	1.0
2	2.5	7.0	9.6	12.2	6.3	4.2	4.6	3.9	2.2	.8	.9	1.2
3	2.8	10.1	8.6	15.0	7.4	4.1	3.8	3.8	1.9	.7	1.0	1.3
4	2.6	10.5	9.0	16.0	9.6	4.1	3.4	3.6	1.8	.6	1.2	2.0
5	2.6	9.4	9.5	26.0	9.6	4.1	3.4	3.3	1.8	.5	1.2	3.3
6	2.7	8.3	12.1	30.4	8.5	4.1	4.0	3.5	1.7	.5	1.3	3.8
7	2.9	8.8	19.2	29.7	7.7	4.4	3.8	4.4	1.7	.5	1.4	3.9
8	3.0	10.7	25.1	25.4	7.2	4.4	3.8	4.2	1.6	.4	1.2	3.5
9	2.8	14.1	24.2	20.0	6.6	4.0	4.4	4.2	1.6	.4	1.2	2.9
10	2.8	15.5	21.3	16.0	6.2	5.2	4.0	5.6	1.4	.4	1.2	2.6
11	2.7	13.2	22.3	14.0	6.0	5.0	4.1	5.2	1.3	.5	1.1	2.4
12	2.6	10.8	28.4	26.0	6.2	5.7	4.5	4.6	1.2	.6	1.0	2.1
13	2.4	9.9	34.9	11.4	7.8	5.0	4.6	4.1	1.2	.9	1.0	1.8
14	2.6	10.0	37.9	10.3	18.4	4.3	4.2	3.5	1.1	1.4	.9	1.8
15	4.1	10.5	37.9	9.7	22.4	3.9	3.8	3.1	1.0	1.1	.8	2.5
16	6.5	10.7	37.0	9.8	20.3	3.6	3.6	2.8	1.0	1.2	.8	2.7
17	6.6	9.8	36.0	10.2	16.5	3.7	4.5	2.8	.9	1.2	.8	2.5
18	6.3	8.6	33.8	9.9	11.9	3.6	6.3	3.0	.9	1.2	.8	2.5
19	6.4	7.6	29.6	9.3	9.1	3.3	6.1	3.4	.8	1.1	.8	2.6
20	6.8	7.0	29.6	8.8	7.7	3.3	5.6	3.0	.8	1.4	.7	3.4
21	7.0	7.0	32.4	8.1	6.9	4.1	6.7	3.0	.9	2.0	.7	4.5
22	7.2	8.3	33.3	7.5	6.4	5.0	6.1	3.4	.9	1.9	.7	7.1
23	7.3	13.2	30.9	7.0	5.9	4.8	5.8	3.1	.8	1.6	.7	10.2
24	7.0	25.2	25.0	6.7	5.6	5.3	6.0	3.8	.9	1.4	.7	9.3
25	6.6	31.6	18.1	6.4	5.3	5.5	8.4	3.4	.8	1.6	.7	7.7
26	5.9	34.8	14.2	6.2	5.1	6.2	9.7	2.9	.8	1.4	.7	6.4
27	5.3	33.8	12.2	6.0	4.8	5.4	13.3	2.8	.7	1.2	.7	5.6
28	4.8	23.6	10.8	6.1	4.6	5.5	8.7	2.8	.7	1.0	.7	5.0
29	4.4	.....	9.8	6.2	4.4	6.2	6.7	2.5	.7	.9	.7	4.5
30	3.7	.....	9.1	5.8	4.2	5.2	5.6	2.2	.8	.8	.9	4.0
31	3.0	.....	8.6	.....	4.2	.....	5.0	2.1	.....	.8	.....	3.8

TOWNSEND STATION ON MISSOURI RIVER.

This station, mentioned in the Eighteenth Annual Report, Part IV, page 123, and described more fully in Bulletin No. 131, page 22, is located on a wagon bridge about a mile north of the railroad station at Townsend, Montana, and immediately below the railroad bridge. The heights given are the means of two daily readings expressed in feet above the St. Louis directrix, which is 412.73 feet above mean gulf level. This gage is maintained by Capt. J. C. Sanford, Corps of Engineers, U. S. A., Sioux City, Iowa, and copies of the record are sent weekly to the office of the Missouri River Commission. The secretary of that commission, Capt. Hiram M. Chittenden, has kindly furnished this office with the record for the year 1897. In the following table, taken from this record, the figures 3,300 have been omitted. It is, therefore, necessary to add 3,300 to obtain elevation above the St. Louis directrix. The following discharge measurements have been made by Roe Emery during 1897:

May 10, gage height, 92.10 feet; discharge, 14,247 second-feet.
May 19, gage height, 92.50 feet; discharge, 19,466 second-feet.
June 12, gage height, 91.00 feet; discharge, 12,352 second-feet.
June 23, gage height, 90.28 feet; discharge, 8,189 second-feet.
July 12, gage height, 89.50 feet; discharge, 5,917 second-feet.
July 27, gage height, 88.85 feet; discharge, 3,797 second-feet.
August 12, gage height, 88.50 feet; discharge, 2,901 second-feet.
September 17, gage height, 88.40 feet; discharge, 2,695 second-feet.

Daily gage height, in feet, of Missouri River at Townsend, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	88.8	92.1	91.5	89.1	90.6	92.5	90.1	88.7	88.2	88.6	88.8	a93.3
2	88.8	92.2	91.4	89.0	90.7	92.7	90.2	88.7	88.2	88.6	88.8	93.3
3	88.8	92.4	91.3	89.0	90.9	92.6	90.2	88.7	88.3	88.6	88.8	93.3
4	88.8	92.5	91.2	89.0	91.2	92.3	90.2	88.7	88.4	88.6	88.7	93.3
5	88.8	92.6	91.1	89.1	91.4	91.9	90.2	88.6	88.4	88.6	88.7	93.3
6	88.6	92.7	91.1	89.1	91.6	91.6	90.2	88.5	88.4	88.6	88.7	93.3
7	88.6	92.8	91.1	89.1	91.7	91.4	90.1	88.5	88.4	88.6	88.7	93.3
8	88.5	92.8	91.1	89.1	91.9	91.3	90.0	88.5	88.4	88.6	88.7	93.1
9	88.5	92.6	91.1	89.2	92.1	91.3	89.8	88.4	88.4	88.6	88.7	92.9
10	88.5	92.6	91.0	89.1	91.9	91.2	89.7	88.4	88.4	88.6	88.7	92.6
11	88.5	92.5	90.0	89.1	91.4	91.1	89.6	88.4	88.4	88.6	88.7	92.3
12	88.5	92.4	90.8	89.2	91.1	91.0	89.4	88.4	88.4	88.6	88.7	92.1
13	88.5	92.4	90.7	89.4	91.1	90.9	89.4	88.4	88.4	88.6	88.7	92.1
14	91.4	92.4	90.7	89.5	91.1	90.8	89.3	88.4	88.4	88.6	88.7	92.2
15	91.4	92.4	90.7	89.8	91.5	90.8	89.2	88.4	88.4	88.6	88.7	92.2
16	91.4	92.3	90.8	90.1	91.8	90.9	89.1	88.4	88.4	88.6	88.7	92.3
17	91.4	92.1	91.1	90.4	92.1	90.9	89.1	88.4	88.4	88.6	88.7	92.3
18	91.4	92.0	91.4	90.6	92.4	90.8	86.1	88.4	88.4	88.7	88.7	92.3
19	91.4	92.0	91.4	90.9	92.4	90.7	89.1	88.4	88.5	88.7	88.7	92.3
20	91.4	91.9	91.4	91.0	92.6	90.5	89.1	88.4	88.4	88.7	88.7	92.3
21	91.4	92.0	91.4	90.8	92.9	90.4	89.1	88.4	88.4	88.8	88.7	92.3
22	91.5	91.9	91.5	90.5	93.0	90.3	89.1	88.4	88.4	88.8	88.7	92.3
23	a92.4	91.8	a91.6	90.2	93.0	90.2	89.0	88.4	88.4	88.8	88.8	92.3
24	92.4	91.7	91.8	90.1	92.8	90.1	89.0	88.4	88.4	88.8	88.8	92.3
25	92.4	91.7	92.4	90.0	92.7	90.1	89.0	88.3	88.4	88.8	88.8	92.3
26	92.4	91.7	93.2	90.2	92.7	90.1	88.9	88.2	88.5	88.8	88.8	92.3
27	92.3	91.7	91.7	90.4	92.5	90.1	88.8	88.2	88.5	88.8	88.8	92.3
28	92.3	91.7	89.9	90.6	92.4	90.1	88.7	88.2	88.5	88.8	88.8	82.3
29	92.2	.....	89.5	90.6	92.3	90.1	88.7	88.2	88.5	88.8	88.8	92.3
30	92.1	.....	89.3	90.6	92.2	90.1	88.7	88.2	88.5	88.8	88.8	92.3
31	92.1	.....	89.2	.....	92.3	.....	88.7	88.2	.....	88.8	.....	92.1

a Ice readings Jan. 23 to Mar. 23, inclusive, and Dec. 1 to Dec. 31, inclusive.

SALESVILLE STATION ON WEST GALLATIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 123, is about 16 miles southwest of Bozeman, Montana, at the highway bridge crossing the stream about 5 miles south of Salesville. The old gage rod erected in July, 1895, is spiked to a tree. In September, 1896, a wire gage was placed on the bridge, the pulley being fastened to the end of the rod opposite the 0.15 foot mark. The distance of the end of the weight to the index marker is 15.50 feet. The two gages were made to read the same. The bed of the stream is rocky and the current is swift.

The bench mark for the wire gage is the head of the southwest bolt in the rim of the southeast cylindrical pier. Its elevation is 13.70 feet above datum. The observer is Ira T. Williams, Salesville, Montana. Discharge measurements were made during 1897, by Roe Emery, as follows:

May 9, gage height, 4.70 feet; discharge, 1,835 second-feet.
May 22, gage height, 6.70 feet; discharge, 5,538 second-feet.
June 5, gage height, 5.40 feet; discharge, 3,221 second-feet.
June 30, gage height, 4.55 feet; discharge, 1,858 second-feet.
July 19, gage height, 3.90 feet; discharge, 1,187 second-feet.
August 10, gage height, 3.50 feet; discharge, 869 second-feet.
September 10, gage height, 3.20 feet; discharge, 533 second-feet.
October 30, gage height, 3.20 feet; discharge, 491 second-feet.

Daily gage height, in feet, of West Gallatin River at Salesville, Montana, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	4.15	6.70	4.50	3.60	3.20	3.20	.....
2	2.90	4.35	6.40	4.50	3.60	3.20	3.25	.....
3	2.90	4.65	5.90	4.65	3.50	3.20	3.30	.....
4	2.90	4.95	5.70	4.40	3.50	3.30	3.20	.....
5	2.90	5.15	5.60	4.50	3.50	3.20	3.20	.....
6	2.90	5.25	5.35	4.40	3.50	3.20	3.20	3.00
7	2.90	5.85	5.30	4.30	3.50	3.20	3.20	.....
8	2.90	5.75	5.20	4.40	3.50	3.20	3.20	.....
9	2.90	5.45	5.35	4.20	3.50	3.20	3.20	.....
10	2.95	4.85	5.70	4.15	3.50	3.20	3.20	.....
11	3.00	4.65	5.30	4.10	3.40	3.20	3.20	3.00
12	3.00	4.65	5.20	4.00	3.40	3.20	3.30	.....
13	2.90	5.15	5.20	4.00	3.40	3.20	3.30	.....
14	2.90	5.40	5.30	3.95	3.40	3.20	3.30	.....
15	3.05	5.75	5.30	3.90	3.30	3.20	3.20	2.90
16	3.10	6.15	5.25	3.90	3.20	3.20	3.20	.....
17	3.20	6.30	5.20	3.90	3.20	3.20	3.20	.....
18	3.35	6.30	5.00	3.90	3.20	3.20	3.20	.....
19	3.50	6.30	5.00	3.90	3.20	3.20	3.20	3.00
20	3.55	6.35	4.90	3.85	3.20	3.20	3.20	.....
21	3.40	6.85	4.70	3.80	3.20	3.20	3.20	.....
22	3.40	6.70	4.70	3.80	3.20	3.20	3.20	.....
23	3.45	6.20	4.70	3.85	3.20	3.20	3.20	.....
24	3.45	6.30	4.65	3.80	3.20	3.20	3.20	.....
25	3.40	6.80	4.55	3.80	3.20	3.20	3.20	.....
26	3.50	6.70	4.50	3.85	3.20	3.20	3.20	3.30
27	3.60	6.00	4.85	3.70	3.20	3.20	3.20	.....
28	3.95	6.00	4.50	3.65	3.20	3.20	3.20	.....
29	4.00	6.15	4.50	3.65	3.20	3.20	3.20	.....
30	3.95	6.30	4.45	3.60	3.20	3.20	3.20	.....
31	.....	6.80	.....	3.60	3.20	.....	3.20	.....

BOZEMAN STATION ON MIDDLE CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 127, is located in Middle Creek Canyon, 9 miles from Bozeman, Montana, and one-eighth of a mile above the old sawmill dam on the road from Bozeman. The gage is about half a mile upstream from the small footbridge which has been placed across the stream for convenience in making discharge measurements. It consists of a vertical post, 4 inches square, secured to a tree stump and protected by the latter from the full force of the current. The bench mark consists of a spike driven horizontally into a stump 5 feet high, about 80 feet east of the gage rod. The middle of this spike is at an elevation of 7.03 feet of the gage. Another bench mark consists of an 8-inch bridge spike driven horizontally into a charred stump about 25 feet northeast of the gage. The top of the spike is at an elevation of 3.58 feet. A third bench mark consists of a large rock 93 feet east of the gage, marked "B. M." in black paint. It is 4.84 feet above datum. Gage heights were not taken in 1897, owing to the impossibility of securing an observer at moderate expense. The following measurements were made during 1897 by Roe Emery:

May 3, gage height, 1.20 feet; discharge, 174 second-feet.
May 21, gage height, 1.20 feet; discharge, 340 second-feet.
June 4, gage height, 0.80 foot; discharge, 233 second-feet,
June 21, gage height, 0.70 foot; discharge, 184 second-feet.
July 6, gage height, 0.65 foot; discharge, 133 second-feet.
July 19, gage height, 0.50 foot; discharge, 108 second-feet.
August 1, gage height, 0.40 foot; discharge, 54 second-feet.
August 10, gage height, 0.30 foot; discharge, 44 second-feet.
September 20, gage height, 0.25 foot; discharge, 42 second-feet.

LOGAN STATION ON GALLATIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 128, is located at Logan, Montana, near the mouth of Gallatin River. The wire gage is placed in the east span of the railroad bridge and fastened to the guard rail on the upper side. The distance from the outside edge of the pulley to the end of the rod is 1 foot; from the end of the weight to the index marker 18.40 feet. Bench mark 1 is the top of the northeast corner of the iron plate at foot of diagonal end member of truss, east end, upper side, and is 13.70 feet above datum. Bench mark 2 consists of the head of a bridge spike driven vertically into the top of the pile stump, to which the lower end of the old inclined gage is fastened, and is 0.38 foot below the 2-foot mark on the gage. Discharge measurements are made from the cable across the river 300 feet above the railroad bridge. The section is a good one, the channel being straight for some distance above and below the cable. The bed is gravelly. The observer is James Martin. The following measurements were made by Roe Emery in 1897:

April 24, gage height, 1.50 feet; discharge, 930 second-feet.
May 4, gage height, 2.30 feet; discharge, 2,708 second-feet.
June 7, gage height, 3.30 feet; discharge, 3,811 second-feet.
July 3, gage height, 1.90 feet; discharge, 1,339 second-feet.
July 16, gage height, 0.70 foot; discharge, 555 second-feet.
July 31, gage height, 0.70 foot; discharge, 459 second-feet.
September 15, gage height, 0.90 foot; discharge, 526 second-feet.
October 6, gage height, 0.90 foot; discharge, 601 second-feet.

Daily gage height, in feet, of Gallatin River at Logan, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	(a)	.....	1.05	1.95	4.60	1.72	0.70	0.70	0.90	1.10	1.35
2	0.95	(a)	.....	1.20	2.00	4.20	1.80	.70	.70	1.15	1.10	1.40
3	.....	(a)	0.80	1.05	2.20	3.70	1.90	.70	.78	1.10	1.10	1.30
4	.....	(a)	.....	1.15	2.32	3.50	1.82	.70	.82	1.00	1.00	1.30
5	.....	(a)	.....	1.50	2.65	3.20	1.70	.70	.80	.90	1.00	1.20
6	1.25	(a)	.90	1.20	3.00	3.10	1.70	.70	.80	.90	1.00	1.10
7	.....	(a)	.....	1.10	3.20	3.10	1.65	.70	.80	.90	1.00	1.10
8	.....	(a)	.....	1.30	3.05	3.15	1.50	.70	.80	.90	1.00	1.10
9	1.20	(a)	.....	1.30	2.70	3.20	1.40	.70	.80	.90	1.00	1.00
10	.....	(a)	1.25	1.30	2.50	3.30	1.30	.70	.80	.90	1.00	1.00
11	.....	(a)	.....	1.30	2.25	3.00	1.20	.70	.80	1.00	1.10	1.00
12	.....	(a)	.....	1.50	2.35	3.00	1.10	.70	.80	1.00	1.10	1.00
13	1.30	(a)	.70	1.30	2.62	3.00	1.00	.70	.80	1.00	1.10	1.00
14	.....	(a)	.....	1.70	2.75	3.10	.90	.70	.80	1.00	1.10	1.00
15	.....	(a)	.....	1.90	3.15	3.00	.80	.70	.80	1.00	1.10	1.10
16	1.50	(a)	.....	1.90	3.45	2.90	.75	.70	.90	1.00	1.10	1.10
17	.....	(a)	.90	1.90	3.75	2.80	.70	.70	.90	1.00	1.10	1.00
18	.....	(a)	.....	1.90	3.85	2.70	.80	.70	.90	1.00	1.20	1.00
19	.....	(a)	.....	1.90	3.88	2.50	1.00	.70	.90	1.00	1.20	(a)
20	1.40	(a)	.95	1.70	4.10	2.40	.85	.70	.90	1.00	1.20	(a)
21	(a)	(a)	.....	1.60	4.28	2.30	.80	.70	.90	1.00	1.20	(a)
22	(a)	(a)	.....	1.50	4.10	2.20	.80	.70	.90	1.05	1.30	(a)
23	(a)	(a)	.....	1.50	3.95	2.20	.80	.70	.90	1.10	1.30	(a)
24	(a)	(a)	1.00	1.50	3.90	2.20	.80	.65	.90	1.10	1.20	(a)
25	(a)	(a)	.....	1.40	4.30	2.10	.78	.65	.90	1.10	1.20	(a)
26	(a)	(a)	.....	1.50	4.70	2.00	.70	.70	.90	1.10	1.10	(a)
27	(a)	0.95	1.80	1.60	3.95	2.00	.70	.70	.90	1.10	1.10	(a)
28	(a)	.....	.....	1.90	3.80	2.00	.70	.70	.90	1.10	1.10	(a)
29	(a)	.....	.....	1.95	3.85	2.00	.65	.70	.80	1.10	1.10	(a)
30	(a)	.....	.....	1.98	3.90	2.00	.60	.70	.80	1.10	1.20	(a)
31	(a)	.....	.....	.....	3.85	.....	.65	.70	.....	1.10	.....	1.03

a Frozen.

REDBLUFF STATION ON MADISON RIVER.

This station is located at the ranch of the observer, Mrs. S. A. Black, 4 miles below the Redbluff iron county bridge over the Madison, and about 1½ miles below the mouth of Cherry Creek. It is also about 3 miles below the location of the old Redbluff station, described in Bulletin No. 131, on page 18. It was established May 2, 1897, at which time the one at Threeforks was discontinued. The vertical gage is fastened to a post set firmly into the bed of the river, and braced with crosspieces from the bank. Discharge measurements are made from the iron bridge above. Cherry Creek is measured at the same time as it enters between the gage and the bridge. The initial point for soundings is at the left abutment of the bridge. The banks are high and do not overflow. The bed of the stream is rocky and the current is quite swift. The following are the discharge measurements made during 1897 by Roe Emery:

Not including Cherry Creek:

April 27, gage height, 1.70 feet; discharge, 1,806 second-feet.

May 7, gage height, 2.45 feet; discharge, 2,803 second-feet.

Including Cherry Creek:

May 26, gage height, 3.70 feet; discharge, 8,467 second-feet.

June 19, gage height, 2.22 feet; discharge, 4,191 second-feet.

July 1, gage height, 1.90 feet; discharge, 2,794 second-feet.

July 14, gage height, 1.65 feet; discharge, 2,241 second-feet.

July 29, gage height, 1.50 feet; discharge, 2,115 second-feet.

September 14, gage height, 1.40 feet; discharge, 1,656 second-feet.

October 4, gage height, 1.50 feet; discharge, 1,940 second-feet.

November 2, gage height, 1.40 feet; discharge, 1,545 second-feet.

Daily gage height, in feet, of Madison River at Redbluff, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.75	1.92	1.60	1.40	1.40	17	2.75	2.50	1.88	1.40	1.40	1.30
2	2.08	3.65	1.92	1.60	1.40	1.40	18	(a)	2.30	1.85	1.40	1.40	1.30
3	2.08	3.55	2.00	1.60	1.40	1.40	19	(a)	2.25	1.80	1.40	1.40	1.35
4	2.15	3.35	2.00	1.60	1.40	1.40	20	(a)	2.25	1.85	1.40	1.40	1.40
5	2.22	3.20	2.00	1.60	1.40	1.40	21	(a)	2.10	1.80	1.40	1.40	1.40
6	2.35	2.50	1.90	1.50	1.40	1.40	22	(a)	2.05	1.70	1.40	1.40	1.40
7	2.45	2.40	2.00	1.50	1.40	1.40	23	(a)	2.10	1.82	1.40	1.40	1.40
8	2.50	2.50	2.00	1.45	1.40	1.40	24	(a)	2.00	1.85	1.40	1.40	1.50
9	2.35	2.60	1.95	1.40	1.40	1.40	25	(a)	2.00	1.70	1.40	1.40	1.50
10	2.28	2.55	1.90	1.40	1.40	1.40	26	(a)	2.00	1.70	1.40	1.35	1.50
11	2.15	2.40	1.90	1.40	1.40	1.40	27	3.75	1.94	1.75	1.40	1.35	1.50
12	2.10	2.30	1.90	1.40	1.40	1.40	28	3.60	1.93	1.70	1.40	1.40	1.50
13	2.15	2.30	1.80	1.40	1.40	1.40	29	3.40	1.90	1.70	1.40	1.40	1.50
14	2.35	2.40	1.80	1.40	1.40	1.40	30	3.45	1.90	1.70	1.40	1.40	1.50
15	2.45	2.45	1.82	1.40	1.40	1.40	31	3.55	.....	1.60	1.40	.....	.....
16	2.65	2.50	1.80	1.40	1.40	1.40							

a Over gage.

THREEFORKS STATION ON MADISON RIVER.

A description of this station was given in the Eighteenth Annual Report, Part IV, page 131. The gage is at the bridge of the Northern Pacific Railroad company, one-half mile from the town of Threeforks. The greater part of the discharge of the river flows under this bridge, but there are a number of small side channels, branching off at points above, through which considerable water flows, especially in time of flood. For this reason the station was discontinued on the 1st of May and one established at the Redbluff iron bridge, 30 miles above. A measurement was made June 8, 1897, which gave a discharge of 4,316 second-feet, at the same time the sloughs were discharging 1,568 second-feet additional. The gage is inclined, the zero being 14.11 feet below the top of the rail on the east end of the bridge.

Daily gage height, in feet, of Madison River at Threeforks, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	.....	2.30	0.90	1.00	1.50	17	1.00	0.90	0.60	0.50	.....
2	.....	2.30	.90	1.00	.....	18	1.50	.90	.60	.50	.....
3	.....	2.30	.80	1.00	.....	19	1.40	.90	.60	.70	.....
4	.....	1.90	.80	2.00	.....	20	1.30	.99	.70	.70	.....
5	.....	2.00	.70	2.00	.....	21	1.20	.90	.70	.60	.....
6	.....	1.70	.70	1.05	.....	22	1.00	.90	.50	.60	.....
7	.....	1.30	.60	1.03	.....	23	.90	.90	.50	.70	.....
8	.....	1.30	.60	.50	.....	24	.90	.90	.40	.70	.....
9	.....	1.30	.60	.40	.....	25	1.00	.90	.40	.80	.....
10	2.00	1.20	.60	.40	.....	26	.80	.90	.30	.80	.....
11	1.51	1.20	.60	.50	.....	27	.80	.90	.20	.90	.....
12	2.25	1.00	.50	.55	.....	28	.80	.90	.80	1.00	.....
13	1.00	1.00	.50	.40	.....	29	.80	.....	.80	1.30	.....
14	2.00	.90	.60	.40	.....	30	.80	.....	.90	1.40	.....
15	1.00	.90	.60	.40	.....	31	1.30	.....	.90	.....	.....
16	1.00	.85	.60	.50	.....						

SAPPINGTON STATION ON JEFFERSON RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 134. The wire gage is fastened to the guard rail, on the upper side, in the east span of the Northern Pacific Railroad bridge, one-fourth of a mile north of Sappington station, Montana. The outside edge of the pulley is 0.2 foot from the end of the rod. The distance from the end of the weight to the index marker is 16 feet. Bench mark 1 consists of a 6-inch wire nail driven horizontally in the east side of the blocking which forms the south abutment of the railroad bridge, and is 6.9 feet on the gage. Bench mark 2 is a 6-inch wire nail driven horizontally into a telegraph pole about 30 feet south and east of the south abutment of the bridge, and is at an elevation of 7 feet on the gage. Bench mark 3 is the head of the northwest bolt fastening the switch standard to the cross-tie, 30 feet east of the bridge. Its elevation is 15.67 feet. On November 3, 1897, the rod was lowered 0.8 foot, by placing its end that distance nearer the pulley, thus making the pulley distance 0.2 foot, subsequent readings being adjusted to the old position. The

section is good, being straight for some distance above and below the cable. The bed of the river is gravelly. The observer is Clem Piper, storekeeper, address, Sand Creek, Montana. The following discharge measurements were made during 1897 by Roe Emery:

April 26, gage height, 2.60 feet; discharge, 3,571 second-feet.
May 6, gage height, 3.85 feet; discharge, 8,293 second-feet.
July 2, gage height, 2.10 feet; discharge, 3,321 second-feet.
July 15, gage height, 1.30 feet; discharge, 2,077 second-feet.
July 30, gage height, 0.80 foot; discharge, 1,116 second-feet.
September 14, gage height, 0.40 foot; discharge, 841 second-feet.
October 5, gage height, 0.50 foot; discharge, 920 second-feet.
Gage heights at Sappington; discharge measured at bridge at Three Forks:
May 27, gage height, 4.20 feet; discharge, 9,704 second-feet.
June 8, gage height, 2.65 feet; discharge, 4,638 second-feet.

Daily gage height, in feet, of Jefferson River at Sappington, Montana, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	2.95	3.65	2.10	0.70	—0.10	0.30	.....	.....
2	.....	3.10	3.75	2.00	.70	— .10	.30	.....	.....
3	.....	3.35	3.60	2.20	.60	— .10	.45	.....	.....
4	.....	3.50	3.40	2.35	.60	— .10	.50	.....	.....
5	.....	3.75	3.25	2.40	.60	+ .10	.50	.....	.....
6	.....	4.00	3.05	2.30	.60	.20	.50	.60	1.60
7	.95	4.45	2.85	2.20	.50	.20	.50	.....	.....
8	.....	4.30	2.65	2.10	.50	.25	.50	.....	.....
9	.....	4.35	2.60	2.00	.50	.30	.50	.....	.....
10	1.00	3.95	2.60	2.00	.50	.30	.50	.....	.....
11	.....	3.60	2.45	1.85	.50	.20	.50	.....	.....
12	.....	3.35	2.25	1.65	.40	.30	.50	.....	1.90
13	.....	3.30	2.00	1.55	.40	.30	.50	.....	.....
14	1.00	3.45	1.90	1.40	.30	.40	.50	.60	.....
15	.....	3.55	1.85	1.25	.30	.40	.55	.....	.....
16	.....	3.80	1.90	1.20	.30	.40	.60	.....	.....
17	.....	3.95	2.10	1.05	.25	.40	.60	.....	.....
18	.....	4.30	2.25	1.10	.20	.40	.60	.....	.....
19	.....	4.50	2.30	1.20	.20	.40	.60	.....	1.80
20	3.90	4.50	2.25	1.20	.20	.40	.60	.....	.....
21	.....	4.50	2.15	1.15	.20	.40	.60	1.90	.....
22	.....	4.45	1.95	1.10	.....	.35	.65	.....	.....
33	.....	4.40	1.80	1.10	.....	.30	.70	.....	.....
24	.....	4.15	1.80	1.10	.....	.30	.80	.....	.....
25	.....	4.00	1.95	1.10	.....	.30	.80	.....	.....
26	2.60	4.05	2.00	1.05	.....	.30	.80	.....	(a)
27	3.00	4.20	1.95	1.00	.....	.30	.80	.....	.....
28	3.35	4.10	2.05	.95	— .10	.30	.80	1.90	.....
29	3.10	3.85	2.25	.85	— .10	.30	.70	.....	.....
30	3.05	3.65	2.20	.80	— .10	.30	.70	.....	.....
31	.....	3.40	.....	.70	— .10	.....	.....	.....	.....

a Frozen.

River frozen Jan. 1 to Apr. 1.

GREAT FALLS STATION ON SUN RIVER.

This station is located on Sun River, 10 miles above its mouth, at Great Falls, Montana. It is at the dam of the Priest Rapids Water Power and Irrigation system. The vertical rod with its zero corresponding to the crest of the dam is fastened to the north abutment. The observer is Mr. I. S. Corson, Great Falls, Montana. A discharge measurement made July 4, 1897, at the highway bridge 5 miles above the dam gave a discharge of 2,108 second-feet. On August 28 a measurement was made at the wagon bridge in the outskirts of West Great Falls about one-half mile above the junction of Sun and Missouri rivers. The gage height was 0.30 foot and the discharge 362 second-feet.

Daily gage height, in feet, of Sun River near Great Falls, Montana, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1	.....	0.64	0.32	0.50	17	1.06	0.71	0.49	0.51
2	.....	.61	.32	.52	18	1.02	.72	.46	.50
3	.....	.62	.37	.50	19	.99	.62	.46	.50
4	.....	.64	.39	.49	20	.94	.60	.46	.51
5	.....	.66	.40	.50	21	.90	.58	.48	.54
6	.....	.65	.40	.49	22	.90	.52	.46	.54
7	.....	.66	.40	.49	23	.88	.50	.48	.52
8	.....	.67	.39	.49	24	.86	.48	.48	.51
9	.....	.68	.40	.50	25	.86	.44	.46	.52
10	.....	.68	.40	.50	26	.84	.39	.46	.53
11	1.07	.67	.42	.52	27	.82	.36	.46	.53
12	1.09	.66	.44	.52	28	.78	.32	.46	.53
13	1.06	.63	.43	.52	29	.73	.30	.46	.54
14	1.06	.68	.46	.50	30	.68	.30	.48	.53
15	1.04	.69	.48	.50	31	.64	.32	.....	.....
16	1.02	.69	.50	.52					

CHINOOK STATION ON MILK RIVER.

This station is located at the wagon bridge over Milk River, 1 mile south of Chinook, Montana. It was established May 25, 1897. The gage rod consists of a vertical timber, marked in feet and tenths, nailed to the south abutment of the bridge. The bench mark is the top of the inside tie rod directly over the gage and is at an elevation of 18.0 feet. The measurements at this point do not give the total discharge of the river, as quite a large canal, that of the Fort Belknap Irrigation Company, is taken out about 10 miles above the station. The observer is Fred E. Neill, rancher. Discharge measurements during 1897 were made by Roe Emery as follows:

May 25, gage height, 1.40 feet; discharge, 110 second-feet.
July 3, gage height, 2.30 feet; discharge, 460 second-feet.
November 10, gage height, 0.72 foot; discharge, 34 second-feet.

Daily gage height, in feet, of Milk River at Chinook, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.15	2.80	0.50	0.10	0.40	17	.....	8.95	1.90	0.30	0.40	0.50
2	.....	1.10	2.60	.50	.10	.40	18	.....	.....	1.80	.30	.60	.30
3	.....	1.30	2.20	.40	.10	.40	19	.....	8.00	1.60	.30	.60	.40
4	.....	1.30	2.00	.50	.10	.30	20	.....	7.00	1.40	.30	.70	.40
5	.....	1.20	2.30	.60	.10	.20	21	.....	6.40	1.00	.20	.70	.40
6	.....	1.10	2.40	.70	.10	.10	22	.....	5.30	.90	.20	.60	.30
7	.....	1.00	2.50	.60	.10	.40	23	.....	5.00	1.00	.20	.50	.30
8	.....	.90	2.60	.60	.10	.50	24	.....	4.00	1.10	.10	.40	.....
9	.....	.90	3.30	.50	.10	.60	25	1.40	3.40	1.00	.10	.30	.....
10	.....	.80	3.10	.40	.10	.40	26	1.60	3.00	.90	.10	.20	.....
11	.....	.80	3.00	.40	.10	.50	27	1.50	3.10	.80	.05	.20	.....
12	.....	1.00	2.80	.30	.10	.40	28	1.50	3.40	.70	.10	.30	.....
13	.....	.90	2.60	.20	.10	.40	29	1.50	3.00	.80	.10	.20	.....
14	.....	.80	2.20	.40	.10	.40	30	1.40	3.20	.60	.10	.20	.....
15	.....	.80	2.00	.30	.10	.60	31	1.20	.....	.60	.10	.....	.....
16	.....	1.40	1.80	.30	.20	.40							

LIVINGSTON STATION ON YELLOWSTONE RIVER.

This station is located at the highway bridge over the Yellowstone River, 5 miles south of Livingston, Montana, at the mouth of the canyon. It was established May 2, 1897, a vertical rod fastened to the face of the pier being first used. A wire gage was afterwards established. Length of cable 18.30 feet; pulley distance, 0.58 foot. The bench mark is the head of the 2-inch nut on the center pin at the foot of the end diagonal of the truss, east pier, upper side, and is 13.44 feet above datum. The left bank is high, and will not overflow. The right bank is low, and during floods a part of the water escapes through a slough on that side, and has to be measured separately. The observer is Thos. S. Carter, rancher. The following discharge measurements were made by Roe Emery during 1897:

April 30, gage height, 1.40 feet; discharge, 3,270 second-feet.
May 17, gage height, 4.50 feet; discharge, 14,127 second-feet.
June 15, gage height, 5.15 feet; discharge, 16,282 second-feet.
June 23, gage height, 4.50 feet; discharge, 13,209 second-feet.
July 8, gage height, 3.85 feet; discharge, 6,611 second-feet.
July 24, gage height, 3.00 feet; discharge, 5,971 second-feet.
August 4, gage height, 2.65 feet; discharge, 4,657 second-feet.
September 23, gage height, 1.40 feet; discharge, 2,121 second-feet.
November 8, gage height, 0.90 foot; discharge, 1,394 second-feet.

Daily gage height, in feet, of Yellowstone River at Livingston, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.70	3.98	2.80	1.88	1.30	1.10	.....
2	1.95	5.88	4.20	2.78	1.85	1.32	1.10	1.00
3	2.25	5.48	4.32	2.68	1.80	1.35	1.10	.....
4	2.60	5.10	4.20	2.68	1.80	1.30	1.05	.....
5	3.05	4.90	4.00	2.70	1.80	1.30	1.05	.....
6	3.40	4.75	3.92	2.68	1.75	1.30	1.10	.....
7	3.75	4.60	3.85	2.70	1.75	1.30	.....	.....
8	3.52	4.90	3.82	2.65	1.75	1.25	.....	.....
9	3.00	5.32	3.72	2.65	1.70	1.25	.....	.....
10	2.68	5.12	3.62	2.65	1.68	1.25	.....	.....
11	2.58	4.94	3.50	2.65	1.60	1.25	.....	.....
12	2.72	5.02	3.50	2.60	1.60	1.30	1.20	.....
13	3.02	5.30	3.40	2.55	1.60	1.40	.....	.....
14	3.70	5.32	3.45	2.48	1.58	1.45	.....	.90
15	4.22	5.18	3.43	2.40	1.60	1.40	.....	.....
16	4.48	5.12	3.35	2.38	1.58	1.30	.....	.....
17	4.55	4.90	3.33	2.33	1.55	1.30	.....	.....
18	4.80	4.70	3.30	2.30	1.50	1.30	.....	.40
19	4.95	4.50	3.18	2.28	1.50	1.30	1.10	.....
20	5.75	4.45	3.15	2.20	1.45	1.25	.....	.....
21	6.10	4.45	3.10	2.20	1.45	1.25	.....	.....
22	6.05	4.45	3.08	2.15	1.40	1.25	.....	.....
23	5.85	4.45	3.03	2.13	1.40	1.25	.....	.....
24	5.78	4.38	3.05	2.10	1.40	1.28	.....	.70
25	6.10	4.30	3.10	2.08	1.38	1.25	.....	.....
26	6.10	4.30	3.05	2.05	1.35	1.25	1.00	.....
27	5.60	4.30	3.05	2.00	1.35	1.18	.....	.....
28	5.55	4.28	2.98	2.00	1.35	1.12	.....	.....
29	5.65	4.02	2.88	1.95	1.32	1.12	.....	.....
30	6.02	3.98	2.85	1.95	1.30	1.15	.....	.....
31	5.95	.....	2.85	1.90	.....	1.15	.....	.85

MISCELLANEOUS DISCHARGE MEASUREMENTS IN MONTANA.

During 1897 a number of discharge measurements shown below were made on streams in the immediate vicinity of Bozeman, Montana, by Roe Emery and others, at points where no gage rods were established:

Bozeman Creek.—May 12, discharge, 91 second-feet; May 29, discharge, 60 second-feet; June 22, discharge, 21 second-feet; July 10, discharge, 21 second-feet; July 23, discharge, 30 second-feet; August 9, discharge, 21 second-feet; September 7, discharge, 21 second-feet; September 27, discharge, 12 second-feet.

Rocky Creek.—May 12, discharge, 143 second-feet; May 29, discharge, 74 second-feet; June 22, discharge, 38 second-feet; July 10, discharge, 23 second-feet; July 25, discharge, 24 second-feet; August 9, discharge, 15 second-feet; September 11, discharge, 12 second-feet.

Shields River.—These measurements were made at the bridge near the mouth of the river, 5 miles east of Livingston: May 17, discharge, 1,708 second-feet; June 15, discharge, 883 second-feet; June 23, discharge, 722 second-feet; July 8, discharge, 798 second-feet; July 24, discharge, 315 second-feet; August 5, discharge, 117 second-feet; September 22, discharge, 59 second-feet.

MEETEETSE STATION ON GREY BULL RIVER.

This station is located at the highway bridge in the town of Meeteetse, Wyoming. The rod is fastened to the first pier from the south bank of the river. The bed of the river is of sandstone and but few places can be found on the stream where the water is not a torrent during May and June. The channel is straight. The rod was established by J. E. Hill in May, 1897. A. C. Thomas is the observer.

The following discharge measurements were made by Elwood Mead and C. T. Johnston during 1897:

June 11, gage height, 4.70 feet; discharge, 1,435 second-feet.
August 23, gage height, 2.60 feet; discharge, 147 second-feet.
August 26, gage height, 2.65 feet; discharge, 158 second-feet.

Daily gage height, in feet, of Grey Bull River at Meeteetse, Wyoming, for 1897.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	3.50	3.30	2.30	17	3.80	3.35	2.90	2.50
2	.....	4.95	3.30	2.30	18	3.50	3.35	2.90	2.50
3	.....	3.80	3.40	2.30	19	3.30	3.05	2.90	2.50
4	.....	3.70	3.30	2.20	20	3.40	3.15	2.80	2.50
5	.....	3.70	3.60	2.10	21	4.10	3.10	2.80	2.40
6	.....	3.60	3.30	2.10	22	4.30	3.05	2.70	2.40
7	.....	3.60	3.20	2.00	23	4.50	3.10	2.70	2.30
8	.....	3.50	3.40	2.00	24	4.10	3.10	2.90	2.20
9	.....	3.50	3.30	2.00	25	4.30	3.25	2.80	2.10
10	.....	3.40	3.50	1.90	26	4.30	3.25	2.70	2.10
11	.....	3.30	3.20	1.90	27	4.10	3.20	2.60	2.20
12	.....	3.50	3.20	2.30	28	4.00	2.95	2.50	2.20
13	.....	3.50	3.30	2.40	29	3.10	3.15	2.40	2.30
14	4.70	3.40	3.10	2.50	30	3.50	3.10	2.40	2.30
15	4.80	3.50	3.00	2.50	31	.....	3.50	2.30	.....
16	4.60	3.55	3.00	2.50					

LOVELL STATION ON SHOSHONE RIVER.

This station is located at Lovell, Wyoming, and was established May 23, 1897. The observer is Henry Cockrell. The rod is securely fastened to the landing pier of the Lovell ferry on the south side of the river. The channel is straight for some distance above and below the rod and a cross section there has a uniform depth. The bed of the river is stable.

The following discharge measurements were made by Elwood Mead and C. T. Johnston in 1897:

May 24, gage height, 2.70 feet; discharge, 8,736 second-feet.
June 2, gage height, 2.40 feet; discharge, 7,310 second-feet.
September 15, gage height, —0.70 foot; discharge, 363 second-feet.

Daily gage height, in feet, of Shoshone River at Lovell, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.00	1.50	0.30	—0.70	—0.70	17	.....	2.00	1.20	—0.30	—0.70	.....
2	.....	2.40	1.90	.10	— .70	— .70	18	.....	1.40	.90	— .40	— .70	.....
3	.....	1.80	1.90	.10	— .70	— .70	19	.....	1.00	.60	— .40	— .70	.....
4	.....	1.40	1.50	.10	— .70	— .70	20	.....	1.20	.40	— .40	— .70	.....
5	.....	1.20	1.00	.10	— .70	— .70	21	.....	1.80	.20	— .50	— .70	.....
6	.....	1.10	.80	.00	— .70	— .70	22	.....	1.70	.30	— .60	— .70	.....
7	.....	1.00	.80	.00	— .70	— .70	23	2.70	2.00	.50	— .50	— .70	.....
8	.....	1.70	1.30	—.10	— .70	— .70	24	2.85	1.80	.40	— .50	— .70	.....
9	.....	2.70	1.00	—.10	— .70	— .70	25	2.70	1.70	.30	— .60	— .70	.....
10	.....	2.10	.90	—.10	— .70	— .70	26	2.70	1.90	.20	— .60	— .70	.....
11	.....	2.00	1.10	.00	— .70	— .70	27	2.10	1.90	.30	— .60	— .70	.....
12	.....	2.30	.90	—.10	— .70	— .70	28	2.10	1.50	.20	— .60	— .70	.....
13	.....	2.50	1.10	—.20	— .70	— .70	29	2.50	1.30	.10	— .60	— .70	.....
14	.....	2.60	1.30	—.20	— .70	— .60	30	.....	1.40	.20	— .60	— .70	.....
15	.....	2.70	1.20	—.30	— .70	— .50	31	.....	.....	.40	— .60	.....	.....
16	.....	2.80	1.00	—.30	— .70	— .70							

SHERIDAN STATIONS ON BIG AND LITTLE GOOSE CREEKS.

These stations are described in the Eighteenth Annual Report, Part IV, pages 136 and 137. The gage on Little Goose Creek is located at Broadway bridge in the town of Sheridan, Wyoming, and about 1,000 feet above the mouth of the creek. The gage rod is firmly fastened to the piles of the bridge. The channel is shifting, being composed of clay and gravel.

The station on Big Goose Creek is located in the northern part of Sheridan, at the Fifth avenue bridge crossing. The rod is securely fastened to the bridge piles and protected from injury by driftwood or ice. The channel is shifting, composed of clay and gravel. The station is below the mouth of Little Goose Creek. The observer for both stations is Felix O'Connor. No measurements of discharge were made of either creek in 1897.

Daily gage height, in feet, of Big Goose Creek at Sheridan, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	3.60	2.50	1.35	17	.....	3.10	1.65	.....
2	.....	3.90	2.45	1.35	18	.....	2.85	1.65	.....
3	.....	3.25	2.40	.....	19	.....	2.65	1.65	.....
4	.....	3.25	2.35	.....	20	.....	2.35	1.65	.....
5	.....	3.10	2.25	.....	21	4.65	2.35	1.65	.....
6	.....	2.90	2.25	.....	22	5.00	2.35	1.65	.....
7	.....	3.05	2.15	.....	23	4.10	2.40	1.60	.....
8	.....	3.15	2.15	.....	24	3.70	2.40	1.60	.....
9	.....	3.40	2.15	.....	25	4.65	2.40	1.60	.....
10	.....	3.40	2.20	.....	26	4.05	2.40	1.60	.....
11	.....	3.15	2.15	.....	27	3.55	2.35	1.60	.....
12	.....	3.15	2.15	.....	28	3.35	2.35	1.50	.....
13	.....	3.30	2.15	.....	29	3.25	2.35	1.50	.....
14	.....	3.15	1.65	.....	30	4.50	2.40	1.40	.....
15	.....	3.05	1.65	.....	31	3.50	.....	1.40	.....
16	.....	3.05	1.65	.....					

Daily gage height, in feet, of Little Goose Creek at Sheridan, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	2.10	1.20	1.00	17	.....	1.60	1.00	.....
2	.....	2.25	1.15	1.00	18	.....	1.25	1.00	.....
3	.....	2.00	1.00	.....	19	.....	1.00	1.00	.....
4	.....	1.95	1.00	.....	20	.....	1.10	1.00	.....
5	.....	2.10	1.00	.....	21	3.05	1.35	1.00	.....
6	.....	1.70	1.00	.....	22	3.00	1.10	1.00	.....
7	.....	2.05	1.00	.....	23	2.55	1.10	1.00	.....
8	.....	2.10	1.00	.....	24	2.40	1.00	1.00	.....
9	.....	2.35	1.00	.....	25	2.35	1.00	1.00	.....
10	.....	2.15	1.00	.....	26	2.40	1.00	1.05	.....
11	.....	2.05	1.00	.....	27	2.40	1.00	1.00	.....
12	.....	2.00	1.00	.....	28	2.50	1.00	1.00	.....
13	.....	2.00	1.00	.....	29	2.60	1.20	1.00	.....
14	.....	1.60	1.00	.....	30	2.00	1.00	1.00	.....
15	.....	1.35	1.00	.....	31	2.00	.....	1.00	.....
16	.....	1.35	1.00	.....					

BUFFALO STATION ON CLEAR CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 138, is located about 4 miles west of Buffalo, Wyoming, the county seat of Johnson County, on what was formerly the Fort McKinney Military Reservation. The observer is Fred Bond. Measurements were begun in 1889, in which year a substantial measuring flume was placed in the channel of the stream. This flume is 24 feet long, 30 feet wide, with sides 7 feet high, and with wings at the sides and a pitched apron at the upper end 12 feet long. The floor is set level in all directions, the upstream edge being even with the grade of the creek channel, and the lower 3 or 4 inches above. It cost $300, and although subjected to rough usage through the practice of floating cord wood and timber down the stream, it is still uninjured, and permits of more accurate measurements than can be obtained at any other gaging station in the State. The following discharge measurements were made by Fred Bond during 1897:

January 3, gage height, 0.35 foot; discharge, 20 second-feet.
February 7, gage height, 0.30 foot; discharge, 17 second-feet.
March 10, gage height, 0.40 foot; discharge, 25 second-feet.

Daily gage height, in feet, of Clear Creek, at Buffalo, Wyoming, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	2.22	1.30	0.65	0.50	.....	.....	.....
2	.....	1.22	1.80	1.15	.60	.50	.....	.....	.....
3	.....	1.22	1.54	1.05	.65	.50	.....	.....	.....
4	.....	1.33	1.42	.95	.65	.50	.....	.....	.....
5	.....	1.45	1.40	1.00	.65	.....	.....	.....	.....
6	.....	1.50	1.47	1.05	.65	.....	.....	0.40	0.45
7	.....	1.93	1.28	1.05	.70	.....	0.45	.....	.....
8	.....	1.79	1.38	1.00	.70	.....	.....	.....	.....
9	.....	1.51	1.57	1.00	.70	.....	.....	.....	.....
10	.....	1.33	1.49	.90	.75	.....	.....	.....	.....
11	.....	1.22	1.39	.90	.80	.....	.....	.....	.....
12	.....	1.17	1.36	.90	.75	.....	.....	.45	.40
13	.....	1.20	1.28	.90	.70	.....	.....	.....	.....
14	.....	1.25	1.29	.90	.70	.....	.....	.....	.....
15	.....	1.44	1.30	.90	.70	.....	.....	.....	.....
16	.....	1.57	1.30	.90	.70	.....	.....	.....	.....
17	1.35	1.60	1.30	.85	.65	.....	.45	.....	.....
18	.....	1.69	1.30	.85	.65	.....	.....	.....	.....
19	.....	1.86	1.30	.90	.65	.....	.....	.45	.....
20	.....	1.35	1.30	.90	.65	.....	.....	.60	.....
21	.....	2.16	1.30	.95	.60	.....	.....	.60	.....
22	.....	1.80	1.15	.90	.60	.....	.....	.60	.....
23	.....	1.68	1.20	.95	.60	.....	.....	.50	.....
24	.....	1.71	1.40	.95	.60	.....	.50	.....	.....
25	.....	1.93	1.35	.90	.55	.....	.....	.....	.40
26	.....	1.97	1.30	.85	.55	.....	.....	.....	.....
27	1.15	1.70	1.25	.75	.55	.....	.....	.....	.....
28	.....	1.54	1.20	.75	.55	.....	.....	.....	.....
29	.....	1.56	1.25	.70	.55	.....	.....	.....	.....
30	.....	1.56	1.30	.65	.55	.....	.....	.40	.....
31	.....	1.62	.....	.65	.55	.....	.40	.....	.40

CRAWFORD STATION ON WHITE RIVER.

This station is about 6 miles southwesterly from Crawford, Nebraska, near the line of the Fremont, Elkhorn and Missouri Valley Railroad. It was established on June 26, 1897, by O. V. P. Stout. The gage is placed against a stop gate in the canal of the Crawford Water Power and Irrigation Company, about one-eighth of a mile below the head. All the water of White River is diverted into this canal, and only an insignificant amount escapes between the head of the canal and the gage. The gage was placed by the canal company and is a vertical rod graduated to tenths of a foot. The observer is George Barclay, ditch rider for the canal company. Discharge measurements were made by O. V. P. Stout and A. B. McCoskey in 1897, as follows:

June 26, gage height, 0.42 foot; discharge, 14.4 second-feet.
July 21, gage height, 0.62 foot; discharge, 14.2 second-feet.
August 14, gage height, 0.60 foot; discharge, 12.1 second-feet.
September 6, gage height, 0.40 foot; discharge, 8.9 second-feet.
September 20, gage height, 0.62 foot; discharge, 10.4 second-feet.
September 21, gage height, 0.64 foot; discharge, 11 second-feet.
October 18, gage height, 0.89 foot; discharge, 15 second-feet.
November 5, gage height, 0.92 foot; discharge, 16 second-feet.

Daily gage height, in feet, of White River at Crawford, Nebraska, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1		0.40	0.40	0.71	17	0.30	0.60	0.70	0.90
2		.40	.40	.70	18	.55	.60	.62	.89
3		.60	.40	.70	19	.80	.60	.68	.87
4		.70	.40	.75	20	.70	.50	.60	.89
5		.70	.40	.73	21	.60	.50	.63	.90
6		.70	.43	.76	22	.55	.55	.68	.90
7		.60	.40	.77	23	.55	.50	.65	.88
8		.60	.43	.76	24	.50	.50	.68	.88
9		.70	.50	.68	25	.65	.50	.69	.82
10		.70	.63	.73	26	.55	.40	.70	.82
11		.70	.65	.75	27	.55	.45	.69	.82
12		.60	.70	.82	28	.65	.40	.69	.91
13	0.40	.55	.65	.86	29	.50	.40	.69	.91
14	.30	.60	.63	.82	30	.50	.45	.70	.91
15	.40	.60	.63	.84	31	.45	.45	.....	.....
16	.35	.60	.60	.84					

FORT NIOBRARA STATION ON NIOBRARA RIVER.

This station was established July 22, 1897, by O. V. P. Stout. It is about three-quarters of a mile southwesterly from Fort Niobrara and about 3 miles east of Valentine, Nebraska. The gage is an oak rod 2 by 4 inches, graduated to tenths of a foot, and fastened in a vertical position by lag screws to a plumb post in the trestle bent which serves as the west pier of the bridge. The zero of the gage is 9.08 feet below the top of the short cap, at the shoe of the north truss at the west end of the bridge; it is also 8.09 feet below the top of the north end of the long pile cap, below the cap above noted; and also 9.17 feet lower than the top of the west side of the iron cap of the north cylinder of the center pier of the bridge. The observer is Giacomo Bevilaqua, private, Company F, Twelfth United States Infantry. Discharge measurements were made by O. V. P. Stout and Adna Dobson in 1897, as follows:

June 24, gage height, 0.59 foot; discharge, 925 second-feet.
July 22, gage height, 0.48 foot; discharge, 883 second-feet.
August 15, gage height, 0.38 foot; discharge, 703 second-feet.
September 5, gage height, 0.46 foot; discharge, 730 second-feet.
October 16, gage height, 0.21 foot; discharge, 845 second-feet.

Daily gage height, in feet, of Niobrara River at Fort Niobrara, Nebraska, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1	.....	0.33	0.41	0.42	17	.....	0.39	0.41	0.17
2	.....	.30	.38	.40	18	.....	.32	.37	.20
3	.....	.45	.36	.40	19	.....	.31	.39	.15
4	.....	.41	.41	.40	20	.....	.31	.36	.14
5	.....	.50	.46	.40	21	.....	.39	.38	.12
6	.....	.50	.41	.38	22	0.51	.39	.45	.19
7	.....	.46	.39	.35	23	.46	.38	.45	.22
8	.....	.47	.34	.30	24	.50	.34	.46	.23
9	.....	.40	.45	.31	25	.44	.31	.48	.28
10	.....	.50	.47	.32	26	.41	.32	.....	.37
11	.....	.34	.45	.32	27	.44	.32	.....	.29
12	.....	.40	.45	.26	28	.44	.32	.....	.22
13	.....	.36	.49	.27	29	.44	.31	.45	.15
14	.....	.37	.50	.23	30	.40	.32	.44	.12
15	.....	.36	.42	.21	31	.40	.39	.....	.....
16	.....	.29	.45	.20					

WOODS LANDING STATION ON LARAMIE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 145, is located at Woods Landing, Wyoming, 26 miles from Laramie, Wyoming, and reached by stage. The measurements of discharge are made from a wagon bridge which spans the river at a point about 400 feet below the location of the gage rod. The bottom of the stream is composed of large granite bowlders. This character of bottom, while it renders the shape and slope of channel practically unchangeable, at the same time adds an element of uncertainty to the gaging results, especially at low-water stages. The permanent gage rod is fixed to a perpendicular post set firmly in the bed of the stream and braced at the top to adjacent trees. It stands about 4 feet from the river bank in a position which protects it from drift. The bench mark is a nail head in a notch on a cottonwood tree, 1 foot in diameter, 6 feet from the rod, and is level with the 7-foot mark on the rod. The observer is S. S. Wood. The following discharge measurements were made by C. T. Johnston in 1897:

April 10, gage height, 0.70 foot; discharge, 69 second-feet.
May 12, gage height, 2.30 feet; discharge, 1,110 second-feet.
May 25, gage height, 4.10 feet; discharge, 3,538 second-feet.
June 1, gage height, 3.60 feet; discharge, 2,509 second-feet.
June 2, gage height, 3.75 feet; discharge, 2,651 second-feet.
June 14, gage height, 2.65 feet; discharge, 1,432 second-feet.
June 26, gage height, 2.00 feet; discharge, 707 second-feet.
June 27, gage height, 2.00 feet; discharge, 706 second-feet.

Daily gage height, in feet, of Laramie River at Woods Landing, Wyoming, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	0.50	1.65	3.70	1.70	0.95	0.70	17.....	.85	3.05	2.95	1.30	0.80	0.60
2....	.50	1.75	3.70	1.70	.90	.70	18.....	1.00	3.15	2.75	1.50	.80	.60
3....	.45	1.85	3.65	1.60	.95	.70	19.....	1.10	3.30	2.55	1.50	.80	.60
4....	.50	2.05	3.55	1.50	1.15	.70	20.....	1.20	3.55	2.45	1.40	.80	.60
5....	.45	2.30	3.20	1.40	1.00	.70	21.....	1.25	3.70	2.35	1.30	.80	.60
6....	.60	2.65	2.85	1.35	1.00	.70	22.....	1.10	3.80	2.25	1.25	.70	.60
7....	.60	2.85	2.65	1.30	.90	.70	23.....	1.05	3.90	2.20	1.20	.70	.60
8....	.60	2.95	2.65	1.30	.90	.70	24.....	1.05	3.85	2.10	1.10	.70	.60
9....	.60	2.90	2.90	1.40	1.00	.70	25.....	1.00	4.05	2.00	1.00	.70	.60
10....	.60	2.85	3.20	1.50	1.00	.70	26.....	1.20	3.95	2.00	1.00	.70	.60
11....	.70	2.45	3.15	1.60	.90	.70	27.....	1.35	3.90	2.00	1.10	.70	.60
12....	.70	2.25	3.25	1.50	.90	.70	28.....	1.40	3.80	2.00	1.10	.70	.60
13....	.75	2.40	3.15	1.45	.80	.70	29.....	1.45	3.75	1.85	1.00	.70	.60
14....	.85	2.55	3.05	1.40	.80	.70	30.....	1.50	3.65	1.80	1.00	.70	.60
15....	.90	2.65	3.15	1.30	.80	.70	31.....	.....	3.75	.....	1.00	.70	.....
16....	.90	2.90	3.05	1.30	.80	.70							

UVA STATION ON LARAMIE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 148, is on the line of the Cheyenne Northern Railway, about 1 mile from the town of Uva, Wyoming. The observer is the railway section man, J. A. Carley. The rod is fixed to the side of one of the cluster of piles in mid-channel which supports the railroad bridge. As the section here is not a suitable place to make the discharge measurements, they are made at the wagon bridge which crosses the stream with one clear span about 1,000 feet below the railroad bridge. Here the river has a sufficient straight stretch above and below the bridge to insure a uniform current. The bed of the river is sandy and liable to change during high water. The bench mark is a spike head on south side of pile at east end of railroad bridge. It is 11.95 feet above zero of gage. The following discharge measurements were made by C. T. Johnston in 1897:

April 12, gage height, 1.85 feet; discharge, 205 second-feet.
May 4, gage height, 3.00 feet; discharge, 830 second-feet.
May 14, gage height, 3.10 feet; discharge, 748 second-feet.
May 15, gage height, 3.00 feet; discharge, 742 second-feet.
May 21, gage height, 3.70 feet; discharge, 1,160 second-feet.
May 29, gage height, 5.15 feet; discharge, 2,432 second-feet.
June 8, gage height, 4.05 feet; discharge, 1,365 second-feet.
June 19, gage height, 3.35 feet; discharge, 817 second-feet.
June 22, gage height, 2.45 feet; discharge, 500 second-feet.
July 10, gage height, 1.05 feet; discharge, 44 second-feet.

Daily gage height, in feet, of Laramie River at Uva, Wyoming, for 1897.

Day.	Jan.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.60	3.00	4.90	1.50	0.80	0.80	0.60
2	1.50	2.60	3.20	5.00	1.40	.70	.80	.60
3	.....	3.70	3.10	5.20	1.40	1.00	.80	.....
4	.....	3.60	3.00	5.00	1.30	2.00	.70	.....
5	.....	3.60	3.00	4.10	1.20	3.40	.70	.....
6	.....	2.40	3.20	4.80	1.00	1.60	.70	.....
7	1.50	1.80	3.20	4.80	1.00	1.50	.65	.....
8	.....	1.70	3.10	4.40	.90	1.40	.65	.....
9	.....	1.60	2.90	3.80	.90	1.40	.65	.....
10	.....	1.60	3.20	3.40	.90	1.40	.65	.....
11	.....	1.50	3.30	3.30	1.00	2.60	.65	.....
12	.....	1.70	3.50	3.70	1.00	2.40	.65	.....
13	.....	1.80	3.30	4.10	1.00	2.00	.60	.....
14	.....	1.80	3.20	3.80	1.00	1.60	.60	.....
15	1.30	1.80	3.00	3.80	.90	1.40	.55	.....
16	.....	2.00	2.90	3.70	.90	1.20	.55	.....
17	.....	2.00	3.00	3.60	.90	1.10	.55	.....
18	.....	4.30	2.90	3.80	.90	1.10	.60	.....
19	.....	4.00	3.10	2.80	.90	1.00	.60	.....
20	.....	4.10	3.20	2.80	.90	1.00	.65	.....
21	.....	4.40	3.60	2.80	.90	1.00	.65	.....
22	.....	4.00	4.10	2.60	.90	1.00	.65	.....
23	.....	3.90	4.70	2.30	.90	1.00	.60	.....
24	.....	3.70	4.90	2.00	.90	1.00	.60	.....
25	.....	3.40	5.10	1.90	.80	1.00	.60	.....
26	.....	3.10	5.20	1.50	.80	.90	.60	.....
27	.....	3.00	5.30	1.70	.80	.90	.60	.....
28	.....	3.00	5.30	1.60	.80	.90	.60	.....
29	.....	2.90	5.20	1.60	.80	.90	.57	.....
30	.....	3.00	4.10	1.50	.80	.80	.57	.....
31	.....	.....	4.80	.....	.90	.80	.....	.....

ORIN JUNCTION STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 150, is located at the bridge of the Cheyenne Northern Railway, near Orin Junction, Wyoming. The rod is fixed upon the mid-channel pier of the railway bridge, and is connected with the following permanent bench mark: Spike on top of cap on the set of piles nearest the water at east end of bridge is 11.52 feet above datum. The bed of the stream is composed of heavy gravel and sand, the cross section being quite uniform. The channel is straight for some distance above and below the station. The section boss, P. J. Burns, is employed as observer. The stream at this station is divided into two permanent main channels by the bridge pier, and at high water there is a third channel to the west of the second pier across which the bridge rests on piles, and at a certain stage of water a long cobble bar running down to the bridge divides this third channel into two, thus making at times four channels altogether. The following discharge measurements were made in 1897 by C. T. Johnston:

April 13, gage height, 2.57 feet; discharge, 1,710 second-feet.
May 3, gage height, 5.50 feet; discharge 8,751 second-feet.
May 13, gage height, 5.40 feet; discharge, 10,434 second-feet.
May 20, gage height, 5.90 feet; discharge, 13,471 second-feet.
May 28, gage height, 6.60 feet; discharge, 16,320 second-feet.
June 7, gage height, 5.55 feet; discharge, 11,622 second-feet.
June 18, gage height, 5.25 feet; discharge, 10,100 second-feet.
June 21, gage height, 4.90 feet; discharge, 8,424 second-feet.

Daily gage height, in feet, of North Platte River at Orin Junction, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	.....	.....	2.88	5.68	6.45	3.38	.9.....	0.72
2	1.90	.....	.....	2.78	.....	6.18	3.35	1.40	.70
3	.....	.....	.....	2.68	5.52	6.40	3.22	1.32	.70
4	.....	.....	.....	.....	5.60	7.00	.....	1.78	.70
5	.....	.....	.....	2.62	5.68	6.90	3.30	1.75	.....
6	.....	2.05	2.30	2.52	5.78	.....	3.32	1.78	.70
7	.....	.....	.....	2.42	5.98	5.45	3.32	2.62	.70
8	1.60	.....	.....	2.32	6.12	5.15	3.15	.....	.70
9	.....	.....	.....	2.25	.....	4.95	2.90	2.08	.62
10	.....	.....	.....	2.20	6.20	4.75	2.65	2.08	.60
11	.....	.....	.....	.....	6.10	4.65	.....	2.00	.60
12	.....	.....	.....	2.42	5.90	5.10	2.42	1.88	.....
13	.....	2.05	2.40	2.55	5.55	.....	2.32	1.78	.82
14	.....	.....	.....	2.68	5.32	5.50	2.30	2.15	.78
15	1.50	.....	.....	2.78	5.15	5.35	2.20	.....	.68
16	.....	.....	.....	3.12	.....	5.35	2.28	1.78	.58
17	.....	.....	.....	3.32	5.32	5.25	2.18	1.52	.50
18	.....	.....	.....	.....	5.60	5.25	.....	1.45	.50
19	.....	.....	.....	4.48	5.85	5.00	2.42	1.35	.65
20	.....	2.20	2.70	4.65	5.98	.....	2.32	1.30	.62
21	.....	.....	.....	5.25	6.08	4.30	2.15	1.22	.62
22	.....	.....	.....	5.90	6.25	4.15	2.02	.....	.60
23	1.75	.....	.....	5.85	.....	3.98	2.00	1.12	.60
24	.....	.....	.....	5.50	6.60	3.88	2.00	1.02	.60
25	.....	.....	.....	.....	6.85	3.80	.....	.92	.60
26	.....	.....	.....	4.48	7.00	3.80	1.92	.82	.....
27	.....	2.15	1.65	4.68	7.18	.....	1.82	.80	.65
28	1.75	.....	.....	4.90	7.20	3.73	1.72	.88	.65
29	.....	.....	.....	5.35	7.05	3.60	2.62	.....	.65
30	.....	.....	.....	5.58	.....	3.48	2.52	.80	.52
31	.....	.....	3.15	.....	6.78	.....	1.42	.78	.....

GERING STATION ON NORTH PLATTE RIVER.

This station is located about 1 mile north of Gering, Nebraska, and was established May 29, 1897, by A. B. McCoskey, assistant State engineer. The gage is on the west side of the bridge within a few feet of the south edge of the main channel of the river, and is a vertical rod graduated to tenths of a foot, and fastened to the bridge pile. The zero of the gage is 6.61 feet below a nail head on top of the west end of the first cap at the south end of the bridge. The observer is C. D. Snyder, who is manager of the mill near the gage. Discharge measurements were made in 1897 by O. V. P. Stout and A. B. McCoskey as follows:

May 29, gage height 3.28 feet; discharge, 23,364 second-feet.
September 11, gage height 0.90 foot; discharge, 500 second-feet.
November 2, gage height 1.02 feet; discharge, 661 second-feet.

Daily gage height, in feet, of North Platte River at Gering, Nebraska, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.00	1.80	1.20	1.10	0.80	17	.....	.....	1.30	1.40	0.90	0.95
2	.....	3.00	1.80	1.10	1.10	.80	18	.....	.....	1.40	1.30	.90	.95
3	.....	3.12	1.80	1.10	1.10	.80	19	.....	.....	1.50	1.20	.90	.95
4	.....	3.30	1.70	1.20	1.00	.80	20	.....	.....	1.30	1.20	.90	.95
5	.....	3.35	1.70	1.10	1.00	.80	21	.....	.....	1.30	1.10	.90	.95
6	.....	.....	1.60	1.10	1.00	.80	22	.....	.....	1.30	1.10	.85	.95
7	.....	.....	1.50	1.10	1.00	.80	23	.....	.....	1.30	1.00	.85	.95
8	.....	.....	1.50	1.30	.90	.80	24	.....	.....	1.30	1.00	.85	1.00
9	.....	.....	1.60	1.30	.90	.80	25	.....	.....	1.30	1.00	.85	1.00
10	.....	.....	1.70	1.50	.90	.85	26	.....	.....	1.30	.90	.85	1.00
11	.....	.....	1.50	1.30	.90	.85	27	.....	.....	1.30	.90	.85	.95
12	.....	.....	1.40	1.30	.90	.85	28	.....	.....	1.30	.90	.85	.95
13	.....	.....	1.40	1.30	.90	.90	29	.....	.....	1.30	.90	.80	.95
14	.....	.....	1.30	1.40	.90	.90	30	3.50	.....	1.20	.90	.80	.95
15	.....	.....	1.30	1.40	.90	.90	31	3.30	.....	1.20	.90	.....	.....
16	.....	.....	1.30	1.40	.90	.90							

CAMP CLARKE STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 153, is located on the right bank of the river, about 40 feet above the bridge at Camp Clarke, Nebraska. The observer is Robert H. Willis, county surveyor of Cheyenne County, Nebraska, who lives about 1 mile from the gage. The gage consists of an oak piece, 2 by 4 inches, 10 feet long. It is fastened to cross-ties, which are bedded in the bank of the river. The face of the rod is inclined at an angle of 30 degrees to the horizontal, so that 2 feet along the rod are equal to 1 foot in the vertical, and the rod is graduated accordingly. The channel at the station is fairly straight, above and below. The bed, as elsewhere along this river, is of loose, coarse sand. Two bench marks were established. The first consists of a spike which is driven horizontally in the northeast side of the downstream pile of the bent at the north end of the first truss span on the south end of the bridge. This spike is 7.55 feet above the zero of the gage. The second bench mark is a point on the southeast corner of the window sill at the front of the store. This point is 9.74 feet above the zero of the gage. A measurement of discharge was made at this station by O. V. P. Stout on September 12, 1897. Gage height 2.11 feet; discharge, 551 second feet.

Daily gage height, in feet, of North Platte River at Camp Clarke, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.91	2.89	2.80	2.85	4.20	4.55	3.35	2.30	2.20	2.03
2	2.90	2.89	2.76	2.82	4.26	4.50	3.30	2.35	2.19	2.02
3	2.90	2.89	2.72	2.81	4.20	4.51	3.15	2.50	2.19	2.05
4	2.85	2.89	2.74	2.78	4.25	4.68	3.10	2.52	2.20	2.04
5	2.85	2.89	2.78	2.74	4.26	4.90	3.03	2.45	2.18	2.05
6	2.80	2.89	2.78	2.68	4.25	5.00	2.99	2.50	2.14	2.06
7	2.80	2.89	2.85	2.75	4.32	4.78	2.91	2.54	2.13	2.06
8	2.80	2.89	2.79	2.84	4.25	4.50	2.91	.....	2.12	2.08
9	2.80	2.89	2.55	2.80	4.35	4.27	3.05	2.61	2.12	2.08
10	2.80	2.89	2.46	2.65	4.30	4.10	3.05	2.79	2.10	2.06
11	2.80	2.89	2.30	2.75	4.50	3.95	2.97	2.79	2.10	2.12
12	2.84	2.89	2.20	2.80	4.46	3.87	2.90	2.65	2.10	2.10
13	2.84	2.89	2.12	2.60	4.40	4.00	2.90	2.68	2.13	2.10
14	2.84	2.83	.....	2.75	4.35	4.03	2.80	2.67	2.12	2.10
15	2.85	2.80	2.57	2.75	4.17	4.10	2.75	2.60	2.15	2.11
16	2.87	2.75	2.59	2.77	4.07	4.03	2.65	2.54	2.15	2.11
17	2.87	2.65	2.57	2.75	3.94	4.05	2.57	2.50	2.16	2.11
18	2.89	2.75	2.52	2.79	4.05	4.10	2.92	2.49	2.14	2.12
19	2.89	2.86	2.45	2.90	4.07	4.08	2.92	2.43	2.17	2.11
20	2.89	2.90	2.40	3.30	4.25	4.08	2.68	2.35	2.15	2.15
21	2.89	2.85	2.40	3.60	4.33	3.89	2.60	2.29	2.13	2.20
22	2.89	2.85	2.42	3.68	4.26	3.89	2.62	.....	2.10	2.21
23	2.89	2.85	2.45	3.95	4.37	3.65	2.60	2.30	2.09	2.19
24	2.89	2.85	2.43	4.28	4.56	3.62	2.65	2.24	2.10	2.18
25	2.89	2.85	2.45	4.28	7.72	3.47	2.58	2.25	2.09	2.19
26	2.89	2.85	2.42	3.95	4.78	3.50	2.52	2.22	2.10	2.21
27	2.89	2.85	2.43	3.88	4.77	3.49	2.57	2.20	2.11	2.22
28	2.89	2.80	2.41	3.80	4.72	3.51	2.52	2.22	2.10	2.20
29	2.89	.....	2.42	3.88	4.74	3.57	2.56	2.22	2.11	2.21
30	2.89	.....	2.45	4.00	4.70	3.40	2.45	2.18	2.06	2.21
31	2.89	.....	2.80	.....	4.67	.....	2.40	2.20	.....	2.21

NORTH PLATTE STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 156, is located at the wagon bridge 1 mile north of the town of North Platte, Nebraska. The water, except in times of flood, does not pass under all the spans of the long bridge, but usually the greater part flows under two or three of these, spreading out in shallow pools or streamlets under others. The initial point for soundings is on the right bank. The channel is nearly straight for about 500 feet, both above and below the station. The gage is at the railroad bridge 2 miles below the wagon bridge. The zero is 12.00 feet below the top and immediately under the east rail of the track. The observer is Fred Hanlon. The following measurements of discharge were made by C. P. Ross, in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 5....	2.70	4,038	June 19 ...	3.35	11,393	Sept. 4 ...	1.65	679
Apr. 12...	2.80	2,961	June 29 ...	3.05	6,518	Sept. 18 ..	1.70	744
Apr. 26...	3.45	10,328	July 10....	2.25	4,112	Oct. 6....	1.50	486
May 17...	3.50	13,486	July 24....	2.05	2,940	Oct. 18...	1.90	1,343
May 29...	4.05	20,796	Aug. 7	2.40	3,118	Nov. 11 ..	1.90	1,511
June 10 ..	3.95	17,172	Aug. 21 ...	2.15	2,306			

Daily gage height, in feet, of North Platte River at North Platte, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.90	2.80	2.50	2.30	3.20	4.10	2.95	1.85	1.75	1.60	2.00	2.30
2	2.85	2.80	2.60	2.55	3.20	4.05	2.80	1.85	1.75	1.50	1.90	2.20
3	3.00	2.80	2.75	2.75	3.25	4.05	2.75	1.85	1.70	1.50	1.80	2.30
4	2.95	2.90	2.85	2.75	3.50	3.90	2.65	1.90	1.65	1.50	1.70	2.30
5	3.00	2.85	2.90	2.85	3.50	3.90	2.55	1.95	1.60	1.50	1.70	2.30
6	3.05	2.85	3.00	2.70	3.45	3.90	2.50	2.45	1.65	1.50	1.80	2.30
7	3.10	2.85	3.05	2.75	3.50	4.10	2.40	2.40	1.55	1.50	1.90	2.30
8	3.15	2.85	3.10	2.85	3.50	4.25	2.35	2.50	1.45	1.50	1.90	2.30
9	3.20	2.95	3.15	2.75	3.65	4.15	2.45	2.40	1.45	1.50	2.00	2.40
10	3.15	3.05	3.25	2.65	3.60	3.90	2.25	2.45	1.50	1.65	2.00	2.45
11	3.15	3.15	3.35	2.65	3.60	3.85	2.10	2.50	1.65	1.55	1.90	2.50
12	3.15	3.15	2.45	2.80	3.65	3.85	2.15	2.35	1.70	1.65	1.90	2.55
13	3.25	3.20	2.50	2.65	3.65	3.55	2.35	2.20	1.60	1.70	1.90	2.70
14	3.25	3.25	2.40	2.55	3.60	3.40	2.10	2.30	1.65	1.65	1.90	2.70
15	3.15	3.25	2.30	2.45	3.65	3.25	2.05	2.45	1.60	1.70	1.90	2.80
16	3.20	3.35	2.25	2.25	3.45	3.35	2.15	2.35	1.65	1.80	1.90	2.80
17	3.20	3.35	2.40	2.25	3.55	3.25	2.15	2.35	1.65	1.85	2.00	2.90
18	3.20	3.35	2.55	2.30	3.45	3.45	2.20	2.35	1.65	1.90	2.00	2.90
19	3.20	3.35	2.25	2.30	3.45	3.25	2.15	2.30	1.60	1.90	2.00	2.90
20	3.20	3.35	2.20	2.35	3.55	3.35	2.35	2.20	1.60	1.80	2.00	2.90
21	3.15	3.35	2.45	2.55	3.50	3.25	2.15	2.15	1.60	1.80	2.00	2.90
22	3.05	3.25	2.40	2.65	3.55	3.25	2.25	2.15	1.60	1.70	1.95	2.90
23	2.90	3.15	2.40	2.85	3.55	3.35	2.40	1.95	1.55	1.70	2.00	2.80
24	2.80	3.05	2.30	3.05	3.60	3.25	2.05	1.90	1.50	1.70	2.00	2.80
25	2.80	2.25	2.05	3.25	3.70	3.25	2.00	1.85	1.35	1.70	1.80	2.70
26	2.90	2.30	2.05	3.45	3.85	3.10	1.95	1.85	1.55	1.85	1.95	2.70
27	2.90	2.30	2.20	3.55	4.00	3.05	1.95	1.80	1.50	1.90	2.15	2.70
28	2.90	2.30	2.10	3.35	4.05	3.10	1.95	1.80	1.50	2.20	2.30	2.60
29	2.90	.....	2.05	3.25	4.05	3.05	1.95	1.75	1.50	2.25	2.30	2.70
30	2.90	.....	2.15	3.20	4.10	3.05	1.90	1.70	1.50	2.20	2.30	2.80
31	2.90	.....	2.20	.....	4.05	.....	1.85	1.70	.....	2.05	.....	2.80

DEANSBURY STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 159, is located about 1,000 feet southwest of Deansbury, Colorado. The discharge measurements are made from a footbridge crossing the stream. The gage rod is vertical. An automatic register is also used. Both banks are high and not liable to overflow.

Station No. 2 is located about 300 feet above station No. 1, and is used during the summer months, being a more desirable point for high-water measurements than station No. 1. The gage consists of a 2 by 4 inch inclined timber. The railroad embankment forms the right bank, while the left is low and subject to overflow at high water. The bed of the stream is rocky and not liable to change. The following measurements of discharge were made by L. R. Hope in 1897:

At Station No. 1:

January 8, gage height, 2.75 feet; discharge, 79 second-feet.
January 16, gage height, 2.68 feet; discharge, 85 second-feet.
January 22, gage height, 2.56 feet; discharge, 68 second-feet.
January 31, gage height, 2.33 feet; discharge, 55 second-feet.
February 17, gage height, 2.58 feet; discharge, 71 second-feet.
March 1, gage height, 2.75 feet; discharge, 90 second feet.
March 11, gage height, 2.82 feet; discharge, 103 second-feet.
March 20, gage height, 2.75 feet; discharge, 92 second-feet.
March 27, gage height, 3.40 feet; discharge, 165 second-feet.
April 8, gage height, 4.17 feet; discharge, 260 second-feet.

At Station No. 2:

April 17, gage height, 2.02 feet; discharge, 342 second-feet.
April 22, gage height, 2.62 feet; discharge, 510 second-feet.
May 3, gage height, 3.05 feet; discharge, 643 second-feet.
May 9, gage height, 3.50 feet; discharge, 831 second-feet.
May 23, gage height, 4.15 feet; discharge 1,006 second-feet.
June 10, gage height, 3.85 feet; discharge, 985 second-feet.
July 1, gage height, 3.15 feet; discharge, 678 second-feet.

Daily gage height, in feet, of South Platte River at Deansbury, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	2.74	2.38	2.63	3.83	2.92	5.25	17.....	2.70	2.56	2.95	2.16	3.82	4.13
2....	2.76	2.39	2.68	3.80	2.97	4.89	18.....	2.70	2.50	2.99	2.42	3.94	3.97
3....	2.70	2.42	2.67	3.95	3.05	4.66	19.....	2.69	2.55	2.96	2.64	3.92	3.79
4....	2.80	2.41	2.69	4.11	2.97	4.40	20.....	2.67	2.54	2.81	2.81	4.04	3.55
5....	2.80	2.40	2.71	4.23	3.00	4.20	21.....	2.63	2.50	2.90	2.80	4.16	3.60
6....	2.80	2.39	2.74	4.22	3.06	4.26	22.....	2.55	2.72	2.78	2.55	3.95	3.56
7....	2.80	2.41	2.80	4.03	3.26	4.19	23.....	2.55	2.63	2.47	2.45	4.07	3.50
8....	2.80	2.75	2.78	1.65	3.30	3.98	24.....	2.53	2.57	2.65	2.38	4.32	3.38
9....	2.62	2.53	2.70	1.66	3.42	3.89	25.....	2.91	2.56	2.91	2.38	4.48	3.32
10....	2.62	2.52	2.58	1.64	3.45	3.85	26.....	3.06	2.55	3.20	2.49	4.43	3.39
11....	2.63	2.68	2.69	1.75	3.61	4.18	27.....	2.41	2.60	3.43	2.77	4.77	3.60
12....	2.63	2.60	2.73	1.77	3.94	4.20	28.....	2.32	2.57	3.64	2.92	4.53	3.58
13....	2.65	2.97	2.70	1.68	3.98	4.23	29.....	2.39	.....	3.84	2.95	4.69	3.65
14....	2.63	2.62	2.62	1.75	3.95	4.23	30.....	2.34	.....	3.99	2.94	4.98	3.50
15....	2.63	2.55	2.82	1.83	3.95	4.37	31.....	2.33	.....	3.72	.....	5.19	.....
16....	2.66	2.50	2.91	1.87	4.08	4.38							

Register move to station No. 2, April 8.

DENVER STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 162, is located at the Fifteenth street bridge, Denver, Colorado, immediately below the mouth of Cherry Creek. The inclined gage consists of two 6 by 2 inch planks spiked together and fastened to posts driven into the river bank. Also, a short vertical rod is spiked to a pile near left abutment of the bridge. The bench mark is 107 feet southwesterly from the gage, and is a cross mark on top of the east abutment of the Fifteenth street bridge, on the north corner. It is marked B. M., and is 15.15 feet above the zero of the gage rod. The river is confined between slag embankments, and the bed is sandy and shifting. The observer is J. H. Hodgson. The following discharge measurements were made by F. Cogswell in 1897:

January 15, gage height, 4.70 feet; discharge, 98 second-feet.
April 15, gage height, 5.35 feet; discharge, 385 second-feet.
May 1, gage height, 5.70 feet; discharge, 595 second-feet.
May 25, gage height, 5.85 feet; discharge, 778 second-feet.
June 4, gage height, 6.45 feet; discharge, 1,311 second-feet.
June 15, gage height, 6.75 feet; discharge, 1,406 second-feet.
July 13, gage height, 5.60 feet; discharge, 687 second-feet.
August 5, gage height, 7.45 feet; discharge, 1,849 second-feet.
August 20, gage height, 5.55 feet; discharge, 473 second-feet.
September 6, gage height, 4.95 feet; discharge, 116 second-feet.
October 11, gage height, 5.70 feet; discharge, 413 second-feet.

Daily gage height, in feet, of South Platte River at Denver, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.55	4.65	4.60	5.40	5.70	6.65	5.35	4.90	5.20	5.20	6.10	5.45
2	4.60	4.70	4.55	5.45	5.65	6.85	5.05	4.85	5.10	5.30	6.05	5.40
3	4.55	4.70	4.60	5.55	5.65	6.65	5.35	6.10	5.00	5.25	6.00	5.25
4	4.50	4.60	4.65	5.50	5.55	6.45	5.15	7.65	4.85	5.35	6.05	5.10
5	4.55	4.70	4.75	5.60	5.50	6.40	5.30	8.25	4.80	5.35	5.90	5.15
6	4.60	4.65	4.80	5.60	5.40	6.45	5.20	7.40	5.10	5.50	5.95	5.25
7	4.75	4.50	4.75	5.70	5.45	6.40	5.10	7.20	5.05	5.40	5.85	5.35
8	4.80	4.55	4.70	5.55	5.45	6.35	5.05	6.00	5.05	5.45	5.70	5.55
9	4.80	4.45	4.80	5.40	5.40	6.30	5.55	5.80	5.20	5.50	5.65	5.45
10	4.75	4.40	4.85	5.30	5.35	6.35	5.95	5.80	5.05	5.55	5.80	5.35
11	4.75	4.35	4.80	5.25	5.55	6.75	5.80	5.70	4.95	5.80	5.85	5.30
12	4.80	4.25	4.85	5.25	5.75	6.80	6.50	5.70	4.70	5.50	5.75	5.40
13	4.75	4.25	4.90	5.30	5.75	6.70	5.75	5.70	5.05	5.35	5.70	5.45
14	4.65	4.25	4.85	5.25	5.65	6.65	5.60	5.60	5.25	5.25	5.75	5.40
15	4.65	4.35	4.85	5.30	5.70	6.65	5.30	5.70	5.40	5.20	5.70	5.35
16	4.70	4.40	4.95	5.40	5.60	6.55	5.00	5.70	5.30	5.30	5.60	5.20
17	4.80	4.55	5.00	5.50	5.70	6.50	4.80	5.70	5.65	5.40	5.50	5.15
18	4.75	4.60	4.90	5.60	5.75	6.35	4.65	5.70	5.20	5.25	5.65	5.10
19	4.70	4.45	5.00	5.80	5.65	6.25	5.55	5.60	5.50	5.30	5.75	5.10
20	4.65	4.40	4.95	5.90	5.80	6.10	5.70	5.55	5.45	5.25	5.80	5.15
21	4.60	4.50	5.00	6.00	6.05	6.00	5.70	5.45	5.40	5.25	5.70	5.20
22	4.65	4.55	5.05	5.60	5.85	5.95	5.55	5.35	5.30	5.25	5.70	5.25
23	4.60	4.65	5.05	5.35	5.80	5.85	5.35	5.38	5.25	5.20	5.60	5.35
24	4.55	4.70	5.10	5.30	5.75	5.75	5.25	5.30	5.30	5.30	5.60	5.35
25	4.50	4.65	5.15	5.20	6.10	5.65	5.30	5.25	5.25	5.35	5.50	5.40
26	4.55	4.75	5.20	5.15	6.05	5.60	5.15	5.20	5.00	5.40	5.30	5.40
27	4.50	4.70	5.25	5.10	6.80	5.75	5.05	5.05	5.30	5.50	5.00	5.35
28	4.55	4.55	5.30	5.25	6.65	5.65	5.10	5.10	5.00	5.75	4.80	5.40
29	4.65	.....	5.35	5.50	6.55	5.65	5.15	5.35	4.85	5.90	4.95	5.55
30	4.70	.....	5.40	5.65	6.70	5.55	5.00	5.35	4.85	5.80	5.25	5.45
31	4.60	.....	5.35	.....	6.60	.....	4.90	5.20	.....	5.95	.....	5.40

ORCHARD STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 166, is located one-fourth mile southwest of Orchard, Colorado. The gage is inclined, consisting of two 2 by 4 inch planks, spiked together and fastened to posts driven into the river bank. It is marked to vertical 0.10 of a foot, the space between the marks being 0.127 of a foot. The bench mark consists of a 2 by 4 inch stick driven almost to the surface of the ground 8 feet back from the rod. The top of this is 8.30 feet above the zero of the gage rod. The initial point for soundings is on the right shore. The left bank is high and the right low and liable to overflow, the bed of the stream being sandy and shifting. Measurements are made by wading. The primary object of this station is to obtain the winter flow of the Platte at this point. The observer is Mrs. U. E. Foley. The following discharge measurements were made by F. Cogswell and others in 1897:

January 18, gage height, 4.14 feet; discharge, 377 second-feet.
May 28, gage height, 5.00 feet; discharge, 1,921 second-feet.
June 20, gage height, 4.60 feet; discharge, 1,926 second-feet.
June 27, gage height, 3.20 feet; discharge, 504 second-feet.
July 25, gage height, 3.60 feet; discharge, 524 second-feet.
September 13, gage height, 2.50 feet; discharge, 86 second-feet.
November 9, gage height, 4.40 feet; discharge, 1,299 second-feet.

Daily gage height, in feet, of South Platte River at Orchard, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.75	4.50	3.80	4.20	3.75	5.80	3.20	3.00	2.75	2.50	4.45	3.90
2	3.80	4.50	3.80	4.30	3.65	6.20	3.10	3.00	2.60	2.50	4.50	5.00
3	3.80	4.50	3.80	4.30	3.40	6.50	3.00	3.00	2.50	2.50	4.50	5.05
4	3.80	4.50	3.80	4.30	3.40	6.30	2.90	3.00	2.50	2.50	4.50	4.70
5	3.85	4.55	3.80	4.30	3.40	6.20	2.35	4.40	2.50	2.50	4.50	4.70
6	3.90	4.55	3.80	4.30	3.35	5.95	2.35	5.30	2.50	2.50	4.50	4.70
7	3.95	4.50	3.80	4.30	3.30	5.40	2.35	5.30	2.50	2.50	4.50	4.75
8	4.25	4.45	3.75	4.35	3.20	4.75	2.30	5.30	2.50	2.50	4.50	4.80
9	4.35	4.40	3.75	4.35	3.00	4.50	2.30	5.40	2.45	2.50	4.40	5.00
10	4.30	4.30	3.75	4.35	3.00	4.50	2.30	5.20	2.45	2.50	4.30	4.90
11	4.35	4.20	3.70	4.40	2.90	5.50	4.00	5.10	2.40	2.50	4.30	4.70
12	4.35	4.10	3.70	4.40	2.80	6.30	3.70	4.50	2.50	2.55	4.20	4.20
13	4.30	4.00	3.70	4.35	2.80	6.50	3.25	4.30	2.50	2.80	4.30	3.90
14	4.30	6.00	4.60	4.30	2.75	6.80	2.50	4.15	2.60	2.80	4.30	4.20
15	4.30	7.00	3.80	4.25	2.70	6.70	2.50	4.00	2.60	2.85	4.20	4.00
16	4.30	6.00	3.70	4.20	2.60	6.40	2.40	4.00	2.60	2.85	4.15	3.60
17	4.30	4.00	3.70	4.20	2.55	6.20	2.35	3.80	2.60	2.90	4.10	3.60
18	4.15	3.90	3.70	4.20	2.50	5.95	2.35	3.70	2.60	3.00	4.10	3.55
19	4.25	3.90	3.70	4.15	2.50	4.75	2.70	3.65	2.60	3.10	4.10	3.70
20	4.35	3.90	3.70	4.15	2.70	4.60	2.95	3.40	2.60	3.20	4.00	3.90
21	4.45	3.85	3.70	4.15	3.20	4.50	3.60	3.35	2.50	3.30	4.00	4.10
22	4.50	3.85	3.70	4.10	4.50	4.40	3.60	3.30	2.45	3.30	4.05	4.10
23	4.55	3.80	3.75	4.10	4.70	4.30	3.90	3.20	2.50	3.35	4.10	4.10
24	4.50	3.80	3.75	4.05	5.00	4.10	3.60	3.00	2.50	3.40	4.00	4.20
25	4.30	3.75	3.80	4.00	5.10	3.95	3.60	2.90	2.50	3.40	4.00	4.30
26	4.25	3.75	3.80	4.00	5.20	3.80	3.60	2.85	2.50	3.45	4.00	4.30
27	4.20	3.75	3.80	3.95	5.30	3.50	3.60	2.85	2.50	3.65	4.00	4.35
28	4.20	3.75	3.80	3.95	5.80	3.30	3.50	2.75	2.50	3.85	4.00	4.40
29	4.35	.....	3.80	3.90	5.80	3.25	3.45	2.75	2.50	4.00	3.90	4.50
30	4.45	.....	3.80	3.85	5.98	3.25	3.30	2.75	2.50	4.20	3.80	4.55
31	4.50	.....	3.90	.....	5.85	.....	3.20	2.75	.....	4.40	.....	4.60

MORRISON STATION ON BEAR CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 167, is located in the upper part of the town of Morrison, Colorado. The gage rod is placed in the river about 150 feet above the railroad depot. It consists of two inclined planks, 2 by 4 inches by 8 feet long, spiked together and fastened to posts driven into the ground. It is divided into vertical tenths of a foot, the space between the marks being 0.127 of a foot. Three nails in a tree in right bank 190.5 feet below gage rod are 10.14 feet above zero of gage. Both banks are low and liable to overflow at high water. Measurements are made by wading, but the bridge above the gage can be used at high water. The observer is Henry Hines. The following measurements of discharge were made by R. S. Sumner and others in 1897:

May 20, gage height, 3.60 feet; discharge, 179 second-feet.
June 13, gage height, 3.70 feet; discharge, 209 second-feet.
June 26, gage height, 3.50 feet; discharge, 162 second-feet.
July 24, gage height, 3.45 feet; discharge, 131 second-feet.
September 11, gage height, 3.05 feet; discharge, 55 second-feet.
October 12, gage height, 3.00 feet; discharge, 52 second-feet.

Daily gage height, in feet, of Bear Creek at Morrison, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.85	3.35	3.20	3.20	3.05	3.00
2	.....	3.65	3.30	3.60	3.15	3.05	3.00
3	3.35	3.55	3.25	4.15	3.15	3.05	2.90
4	3.35	3.60	3.20	5.05	3.16	3.05	2.90
5	3.35	3.60	3.20	4.75	3.15	3.05	2.90
6	3.45	3.65	3.20	4.10	3.05	3.05	2.90
7	3.40	3.55	3.15	4.15	3.05	3.05	2.85
8	3.35	3.55	3.35	3.90	3.05	3.05	2.85
9	3.30	3.55	3.95	3.80	3.05	3.15	2.90
10	3.35	3.55	3.80	3.75	3.05	3.05	3.00
11	3.25	3.80	3.45	3.65	3.05	3.05	3.00
12	3.25	3.85	3.40	3.65	3.05	3.00	3.00
13	3.35	3.75	3.30	3.50	3.05	3.00	3.00
14	3.45	4.00	3.25	3.45	3.15	3.00	3.00
15	3.45	3.70	3.25	3.55	3.35	3.00	3.00
16	3.55	3.65	3.25	3.55	3.25	3.00	3.00
17	3.35	3.55	3.25	3.55	3.15	3.00	2.90
18	3.45	3.55	3.30	3.45	3.15	3.00	2.90
19	3.45	3.55	3.50	3.45	3.15	3.00	2.90
20	3.55	3.55	3.45	3.45	3.15	3.00	2.90
21	3.55	3.50	3.35	3.35	3.15	3.00	2.90
22	3.45	3.45	3.35	3.35	3.10	3.00	2.90
23	3.45	3.45	3.45	3.30	3.05	3.00	2.85
24	3.65	3.45	3.45	3.25	3.05	3.00	2.45
25	3.75	3.40	3.35	3.25	3.05	3.00	2.50
26	3.55	3.45	3.35	3.25	3.05	3.00	2.50
27	3.80	3.50	3.25	3.25	3.05	3.00	2.50
28	3.65	3.45	3.25	3.25	3.05	3.15	2.55
29	3.75	3.45	3.20	3.25	3.00	3.15	2.70
30	3.80	3.40	3.20	3.25	3.05	3.10	2.70
31	3.80	.....	3.20	3.25	.....	3.10	.....

MARSHALL STATION ON SOUTH BOULDER CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 169, is located about 3 miles west of Marshall, Colorado. The gage consists of an inclined 2 by 6 inch timber, with a 1 by 6 inch scale nailed to it, and is fastened to a tree and to stakes driven into the ground. It is marked to vertical 0.10 of a foot, the distance between the marks being 0.22 of a foot. The bench mark is a stone, 15 feet northwest of the gage, marked with black paint. Its elevation is 6.99 feet above zero of rod. Measurements are usually made by wading near the gage, but a footbridge 20 feet above can be used in high water. The Community Ditch and the South Boulder and Coal Creek Ditch both take out water above the gage, and this amount must be added to the discharge at the station to obtain total run-off of the drainage basin of the creek. The observer is C. E. Barber. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 22, gage height, 2.45 feet; discharge, 348 second-feet.
June 19, gage height, 2.69 feet; discharge, 363 second-feet.
June 25, gage height, 2.50 feet; discharge, 370 second-feet.
July 27, gage height, 1.65 feet; discharge, 122 second-feet.
August 13, gage height, 1.55 feet; discharge, 116 second-feet.
October 14, gage height, 0.82 foot; discharge, 14 second-feet.

Daily gage height, in feet, of South Boulder Creek at Marshall, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.25	2.40	1.65	1.25	1.15	1.20
2	1.60	3.10	2.40	1.65	1.25	1.15	1.00
3	1.70	2.75	2.40	1.75	1.20	1.10	1.00
4	1.65	2.55	2.25	2.25	1.15	1.05	1.10
5	1.90	2.55	2.10	2.25	1.10	1.10	.90
6	1.95	2.35	2.20	2.20	1.00	1.20	.90
7	1.85	2.30	2.10	2.25	.90	1.25	.85
8	2.00	2.30	2.10	1.85	1.10	1.25	.85
9	2.00	2.30	2.80	1.80	1.10	1.30	.95
10	1.90	2.50	2.60	1.65	1.15	1.10	.90
11	1.85	3.40	2.35	1.65	1.10	1.10	1.00
12	1.75	3.10	2.25	1.60	1.15	.95	1.15
13	1.75	3.10	2.15	1.60	1.15	.90	1.15
14	1.90	2.90	2.15	1.65	1.20	.85	1.20
15	2.05	2.85	2.10	1.60	1.20	.85	1.15
16	2.10	2.95	2.00	1.55	1.25	1.25	1.15
17	2.15	2.85	2.00	1.55	1.30	1.05	1.15
18	2.20	2.50	2.05	1.55	1.20	1.00	1.05
19	2.30	2.60	2.05	1.45	1.10	1.00	1.05
20	2.50	2.60	1.85	1.35	1.15	.90	1.05
21	2.50	2.60	1.85	1.35	1.15	.95	1.05
22	2.55	2.60	1.75	1.35	1.10	.95	1.15
23	2.65	2.60	1.80	1.35	1.05	.90	1.05
24	2.95	2.45	1.75	1.40	1.05	.90	1.10
25	3.00	2.55	1.75	1.40	1.00	1.05	1.05
26	2.85	2.80	1.70	1.30	1.00	1.25	1.00
27	3.25	2.65	1.70	1.35	1.00	1.00	1.10
28	3.05	2.45	1.65	1.40	1.05	1.20	.95
29	3.15	2.35	1.60	1.40	1.10	1.25	.95
30	3.15	2.30	1.60	1.35	1.05	1.10	.85
31	3.05	.....	1.65	1.30	.....	1.15	.....

BOULDER STATION ON BOULDER CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 171, is located about 1½ miles above the town of Boulder, Colorado. The gage rod consists of an inclined 2 by 6 inch timber, with a 1 by 6 inch scale fastened to it, and spiked to stakes driven into the ground. It is marked to vertical 0.10 of a foot, the space between the marks being 0.207 of a foot. The bench mark is a large stone, 20 feet north of the gage. Its elevation is 9.95 feet above the zero of the rod. The observer is Mrs. Carrie Osgood. Both banks are high and rocky, and not liable to overflow. The bed of the creek is quite rocky. Measurements are usually made by wading, but during high water can be made from a bridge 40 feet above the gage. On June 14, 1897, this bridge was carried out by a flood. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 21, gage height, 2.15 feet; discharge, 377 second-feet.
July 26, gage height, 1.75 feet; discharge, 298 second-feet.
August 12, gage height, 1.55 feet; discharge, 224 second-feet.
October 13, gage height, 0.55 foot; discharge, 48 second-feet.

Daily gage height, in feet, of Boulder Creek at Boulder, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.35	2.68	2.12	1.62	1.00	0.62	0.40
2	1.40	2.50	2.15	1.75	.95	.65	.43
3	1.42	2.28	2.20	2.00	.95	.60	.55
4	1.45	2.12	2.48	2.20	.90	.60	.53
5	1.50	2.02	1.90	2.15	.85	.55	.50
6	1.50	2.00	1.85	1.92	.80	.58	.45
7	1.55	1.90	1.85	1.78	.80	.70	.48
8	1.65	1.90	2.20	1.80	.75	.95	.52
9	1.60	2.10	2.85	1.70	.75	.78	.55
10	1.60	3.62	2.55	1.68	.78	.72	.50
11	1.55	3.05	2.38	1.58	.88	.70	.45
12	1.45	2.72	2.15	1.58	1.05	.65	.40
13	1.50	2.75	2.08	1.52	1.08	.58	.48
14	1.58	2.70	2.08	1.45	1.28	.55	.50
15	1.80	2.80	2.00	1.40	1.18	.60	.38
16	1.85	2.75	1.98	1.40	1.12	.68	.25
17	1.85	2.58	1.90	1.38	1.08	.70	.38
18	1.90	2.35	1.92	1.35	1.00	.63	.48
19	2.12	2.32	2.00	1.35	.92	.58	.55
20	2.20	2.40	1.90	1.32	.90	.55	.52
21	2.18	2.45	1.80	1.30	.85	.60	.55
22	2.18	2.50	1.65	1.25	.82	.55	.50
23	2.30	2.48	1.70	1.22	.70	.53	.52
24	2.42	2.42	1.82	1.18	.68	.48	.55
25	2.50	2.42	1.88	1.12	.65	.50	.45
26	2.48	2.50	1.75	1.08	.65	.42	.30
27	2.62	2.40	1.70	1.05	.60	.38	.28
28	2.45	2.35	1.62	1.37	.60	.42	.45
29	2.45	2.28	1.60	1.12	.60	.50	.75
30	2.42	2.25	1.55	1.02	.65	.45	.97
31	2.48	.....	1.60	1.05	.....	.43	.....

LYONS STATION ON ST. VRAIN CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 172, is located one-half mile southeast of Lyons, Colorado, below the intersection of the north and south forks of St. Vrain Creek. The Supply ditch takes water out on the left side of the stream, above the gage. To obtain the total run-off of the drainage basin of the creek at this station, the amount of water in the ditch will have to be added to the discharge of the creek. The gage is an inclined 2 by 4 inch timber, marked to vertical 0.10 of a foot, the space between the marks being 0.134 of a foot, and is fastened to posts driven into the ground. Both banks are low and liable to overflow, and the bed of the stream is composed of gravel. Measurements are usually made by wading, but at high water can be made from a wagon bridge 400 feet below the gage. The observer is Miss Bessie Sites. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 25, gage height, 4.15 feet; discharge, 659 second-feet.
June 17, gage height, 4.40 feet; discharge, 713 second-feet.
June 28, gage height, 3.70 feet; discharge, 551 second-feet.
July 20, gage height, 3.10 feet; discharge, 379 second-feet.
September 15, gage height, 2.10 feet; discharge, 115 second-feet.
November 10, gage height, 1.75 feet; discharge, 54 second-feet.

Daily gage height, in feet, of St. Vrain Creek at Lyons, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.95	3.65	2.85	2.15	1.85	1.65
2	3.08	4.55	3.55	2.85	2.15	1.85	1.65
3	3.05	4.05	3.75	3.00	2.05	1.85	1.60
4	2.95	3.60	3.35	3.10	2.05	1.85	1.60
5	3.00	3.50	3.25	3.75	2.05	1.75	1.60
6	3.05	3.45	3.35	3.10	2.05	1.75	1.55
7	3.05	3.35	3.45	2.95	2.05	1.75	1.55
8	3.20	3.55	3.50	2.85	2.00	1.75	1.55
9	3.15	4.15	4.95	2.75	2.00	1.75	1.60
10	3.15	4.35	4.55	2.75	2.05	1.75	1.60
11	3.10	5.45	3.80	2.70	2.05	1.75	1.60
12	3.00	5.25	3.50	2.75	1.95	1.75	1.55
13	3.05	5.10	3.50	2.65	2.25	1.65	1.55
14	3.10	5.00	3.45	2.65	2.30	1.65	1.55
15	3.25	5.10	3.70	2.55	2.25	1.65	1.55
16	3.35	5.10	3.35	2.55	2.35	1.65	1.55
17	3.35	4.35	3.40	2.55	2.25	1.80	1.65
18	4.65	4.00	3.35	2.55	2.25	1.70	1.65
19	3.70	3.80	3.55	2.55	2.15	1.65	1.65
20	3.60	4.00	3.45	2.65	2.05	1.65	1.65
21	3.70	4.20	3.25	2.55	2.05	1.65	1.65
22	3.55	4.10	3.20	2.55	2.05	1.65	1.65
23	3.90	4.25	2.85	2.55	2.05	1.65	1.65
24	4.10	4.00	3.20	2.65	1.95	1.65	1.65
25	4.30	4.00	3.05	2.55	1.95	1.55	1.65
26	4.25	4.30	2.95	2.35	1.95	1.55	1.75
27	4.80	3.85	2.95	2.35	1.95	1.55	1.75
28	4.45	3.85	2.75	2.35	1.85	1.65	1.65
29	4.25	3.75	2.85	2.35	1.85	1.65	1.55
30	4.40	3.65	2.75	2.25	1.85	1.65	1.55
31	4.40	.....	2.85	2.15	.....	1.65	.....

ARKINS STATION ON BIG THOMPSON RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 174, is located about 9 miles west of Loveland, Colorado, and about 600 feet below the Home Supply Dam. The gage is vertical, unpainted, but notched for each foot and 0.10 of a foot, and is fastened to the timbers of a bridge. The bench mark is a notch in a tree about 50 feet below the gage, on the left-hand side of the stream. Its elevation is 4.92 feet above the zero of the rod. The right bank is high, but the left is low, and liable to overflow at high water. The bed of the stream is of gravel, with some bowlders. Measurements are usually made from the upper side of the wagon bridge. The head gates of the Home Supply Ditch and Handy Ditch are located above the dam. The observer is E. Chasteen. The following measurements of discharge were made by R. S. Sumner and others in 1897:

May 26, gage height, 2.45 feet; discharge, 804 second-feet.
June 18, gage height, 1.60 feet; discharge, 400 second-feet.
June 29, gage height, 1.50 feet; discharge, 409 second-feet.
July 21, gage height, 1.20 feet; discharge, 214 second-feet.
September 16, gage height, 0.60 foot; discharge, 61 second-feet.
November 11, gage height, 0.65 foot; discharge, 79 second-feet.

Daily gage height, in feet, of Big Thompson River at Arkins, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.60	2.40	1.30	1.20	0.40	0.40	0.10
2	.85	1.85	1.30	1.15	.40	.40	.10
3	.65	1.55	1.30	1.15	.40	.30	.20
4	1.00	1.35	1.15	1.30	.45	.30	.50
5	.95	1.25	.95	1.55	.30	.30	.45
6	1.25	.45	.95	1.25	.30	.25	.50
7	1.40	.40	1.10	1.15	.30	.15	.50
8	1.45	1.30	1.30	1.10	.30	.20	.45
9	1.45	1.75	1.70	1.10	.35	.35	.50
10	1.40	1.90	1.65	1.10	.40	.30	.35
11	1.40	2.55	1.40	1.05	.40	.30	.00
12	1.35	2.40	1.30	1.00	.55	.20	.00
13	1.35	2.35	1.20	.90	.65	.10	.00
14	1 50	2.10	1.40	1.00	.70	.10	.00
15	1.70	2.25	1.65	.85	.65	.08	.00
16	1.75	2.20	1.45	.70	.55	.08	.00
17	1.60	1.75	1.35	.80	.60	.08	.00
18	1.70	1.50	1.45	.65	.45	.10	.00
19	1.75	1.70	1.50	.60	.35	.00	.15
20	1.95	1.55	1.40	.70	.30	.00	.30
21	2.05	1.75	1.10	.60	.20	.00	.30
22	1.85	1.65	1.15	.60	.15	.00	.25
23	2.10	1.65	1.15	.60	.35	.00	.25
24	2.05	1.55	1.40	.55	.30	.00	.25
25	2.15	1.65	1.25	.45	.30	.00	.25
26	2.05	1.80	1.15	.40	.25	.00	.25
27	2.10	1.70	1.15	.50	.20	.00	.45
28	1.85	1.40	1.00	.50	.20	.00	.45
29	1.90	1.40	1.00	.55	.20	.25	.45
30	1.90	1.35	1.00	.60	.35	.50	.45
31	2.15	.....	1.10	.55	.....	.20	.....

ST. PAUL STATION ON NORTH LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 176, is located on the left bank, at the lower side of the wagon bridge, 4 miles north of St. Paul, Nebraska. The gage consists of a piece of oak, 2 by 3 inches, 16 feet long, with the face inclined 30 degrees to the horizontal. This rests upon cross-ties well bedded and covered, the bottom of the rod being thrust into the bed of the river. The zero of this rod is 15.01 feet below the top of the lower horizontal projecting part of the footplate at the north end of the west truss of the north span of the bridge. Bench mark 2 is the standard iron pipe with brass cap of the United States Geological Survey. It is set with the top 5 inches above the ground and 169 feet north of the gage rod. Its elevation is 6.54 feet above zero of gage. The observer is James Stout, jr. The bed of the river is sandy and is liable to change during floods. The following measurements of discharge were made by Adna Dobson and O. V. P. Stout in 1897:

April 20, gage height, 2.89 feet; discharge, 1,281 second-feet.
May 11, gage height, 2.85 feet; discharge, 1,080 second-feet.
May 28, gage height, 2.76 feet; discharge, 1,064 second-feet.
June 19, gage height, 2.94 feet; discharge, 933 second-feet.
July 17, gage height, 2.66 feet; discharge, 615 second-feet.
July 28, gage height, 2.85 feet; discharge, 708 second-feet.
August 18, gage height, 2.82 feet; discharge, 659 second-feet.
October 10, gage height, 2.92 feet; discharge, 819 second-feet.
October 31, gage height, 3.17 feet; discharge, 1,525 second-feet.

Daily gage height, in feet, of North Loup River at St. Paul, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	2.86	2.95	2.65	3.80	2.78	2.75	2.91
2	3.85	3.70	3.70	3.04	2.93	2.70	3.48	2.75	2.75	2.90
3	.....	.....	.....	3.82	2.90	2.76	4.02	2.75	2.85	2.92
4	.....	3.72	3.78	3.90	2.94	2.84	3.12	2.75	2.79	2.85
5	3.80	.....	.....	2.80	2.92	2.82	3.13	2.81	2.80	2.85
6	.....	3.72	3.79	2.78	2.93	2.81	2.97	2.76	2.83	2.88
7	.....	.....	.....	2.70	2.95	2.79	2.95	3.12	2.84	2.88
8	4.00	3.75	.....	2.63	2.90	2.83	2.97	2.98	2.85	2.87
9	.....	.....	3.80	2.68	2.92	2.80	2.74	2.95	2.73	2.91
10	4.40	3.85	3.86	2.64	2.87	2.78	2.81	2.96	3.35	2.91
11	.....	.....	4.08	3.11	2.87	2.78	2.83	2.87	3.00	2.90
12	.....	3.88	4.22	3.12	2.85	2.77	2.81	2.84	2.97	2.88
13	4.70	.....	a2.84	3.10	2.82	2.78	2.87	2.82	2.95	2.93
14	.....	3.90	2.82	3.07	2.88	2.90	2.83	2.85	2.92	2.95
15	4.50	.....	2.80	3.05	2.85	2.95	2.75	2.82	2.89	2.97
16	.....	3.92	2.83	2.96	2.85	2.95	2.67	2.82	2.89	3.04
17	.....	.....	.....	2.95	2.81	2.90	2.80	2.90	2.85	3.32
18	4.20	3.98	2.80	2.95	2.79	3.00	2.76	2.91	2.84	3.25
19	.....	.....	.....	3.04	2.76	2.94	2.89	2.85	2.84	3.01
20	.....	3.95	2.86	2.88	2.77	2.90	2.79	2.82	2.86	3.12
21	.....	.....	.....	2.93	2.76	3.70	2.77	2.83	2.86	3.05
22	.....	4.00	2.85	2.98	2.75	3.50	2.75	2.80	2.83	3.02
23	.....	.....	2.85	3.02	2.77	3.30	2.78	2.85	2.85	3.02
24	.....	3.62	.....	2.87	2.76	3.10	2.80	2.79	2.85	3.00
25	.....	.....	2.90	2.85	2.75	2.98	2.83	2.77	2.84	3.08
26	3.78	3.62	.....	2.77	2.75	2.71	2.80	2.75	2.87	3.05
27	.....	.....	3.12	2.79	2.75	.....	2.94	2.73	2.82	3.03
28	3.82	3.62	.....	2.83	2.70	3.89	2.81	2.75	2.83	3.00
29	.....	.....	.....	2.89	2.68	3.80	2.79	2.80	2.82	3.02
30	3.80	.....	.....	2.90	2.68	4.64	2.75	2.77	2.85	3.01
31	.....	.....	.....	.....	2.67	.....	2.74	2.73	.....	.....

a Ice going out.

ST. PAUL STATION ON MIDDLE LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 179, is located on the right bank of the stream, at the lower side of the wagon and railroad bridge, 1 mile south of St. Paul, Nebraska. The gage consists of an oak stick, 2 by 3 inches, 16 feet long, inclined 30 degrees to the horizon. This is securely fastened to cross-ties bedded in the soil. The zero of the rod is 9.62 feet below the bottom of the downstream end of the cap of the first river bent at the south end of the bridge. Bench mark 2 is the regulation 4-foot iron post of the United States Geological Survey, and is placed with its top 3 inches above the ground, 50 feet southeast of the gage, and 100 feet at right angles from line of downstream rail of bridge. Its elevation is 7.35 feet above the zero of the gage. The observer is A. C. Snyder, a farmer, who lives one-third mile distant. The following measurements of discharge were made by Adna Dobson and O. V. P. Stout in 1897:

April 21, gage height, 1.74 feet; discharge, 1,792 second-feet.
May 11, gage height, 1.77 feet; discharge, 1,441 second-feet.
May 27, gage height, 1.84 feet; discharge, 1,256 second-feet.
June 18, gage height, 1.87 feet; discharge, 979 second-feet.
July 16, gage height, 1.58 feet; discharge, 816 second-feet.
July 27, gage height, 1.56 feet; discharge, 666 second-feet.
August 18, gage height, 1.65 feet; discharge, 661 second-feet.
October 9, gage height, 1.70 feet; discharge, 814 second-feet.
October 30, gage height, 1.68 feet; discharge, 1,671 second-feet.

Daily gage height, in feet, of Middle Loup River at St. Paul, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.50	2.40	.....	1.78	1.43	1.66	2.64	1.42	1.67	1.60
2	1.20	.....	2.26	1.95	1.50	1.60	2.60	1.48	1.60	1.58
3	.....	.....	3.59	2.40	1.54	1.94	2.17	1.50	1.55	1.65
4	.....	2.35	3.20	2.35	1.60	1.86	1.85	1.49	1.48	1.72
5	.....	.....	.....	1.80	1.65	1.86	1.75	1.67	1.50	1.76
6	2.00	.....	.....	1.95	1.68	1.67	1.68	1.75	1.62	1.68
7	2.20	.....	3.61	1.89	1.65	1.76	1.65	1.71	1.44	1.65
8	2.45	2.31	.....	1.78	1.70	1.75	1.58	1.95	1.38	1.67
9	2.57	.....	.....	1.63	1.78	1.74	1.55	1.92	1.43	1.64
10	.....	.....	3.00	1.66	1.75	1.79	1.69	2.25	1.74	1.78
11	2.89	.....	2.26	1.80	1.77	1.90	1.70	1.78	1.70	1.82
12	.....	2.33	1.45	2.25	1.72	1.85	1.78	1.85	1.73	1.80
13	2.88	.....	.....	2.03	1.78	1.77	1.72	1.77	1.76	1.68
14	2.87	.....	.....	2.25	1.76	1.80	1.55	1.75	1.71	1.80
15	2.70	.....	1.50	2.05	1.63	1.86	1.50	1.73	1.74	1.72
16	.....	2.30	.....	1.90	1.65	1.84	1.47	1.68	1.72	1.83
17	.....	.....	2.10	1.90	1.67	1.89	1.53	1.64	1.65	1.90
18	.....	2.38	2.10	1.65	1.77	1.87	1.60	1.60	1.63	1.90
19	2.47	.....	1.85	1.60	1.73	1.83	1.61	1.66	1.68	1.86
20	.....	2.74	1.86	1.63	1.68	1.68	1.72	1.63	1.65	1.80
21	.....	.....	.....	1.75	1.86	1.70	1.67	1.65	1.67	1.73
22	.....	.....	1.91	1.70	1.68	1.75	1.64	1.64	1.69	1.75
23	.....	.....	1.90	1.58	1.80	1.77	1.71	1.67	1.70	1.78
24	.....	2.15	.....	1.77	1.73	1.68	1.68	1.65	1.68	1.76
25	.....	.....	1.70	1.86	1.77	1.70	1.68	1.51	1.65	1.73
26	2.40	2.00	1.70	1.78	1.73	1.87	1.70	1.48	1.71	2.20
27	.....	.....	.....	1.80	1.83	1.92	1.58	1.50	1.64	2.55
28	.....	.....	.....	1.75	1.78	1.79	1.55	1.56	1.68	1.98
29	.....	.....	.....	1.88	1.75	1.77	1.67	1.64	1.50	1.80
30	.....	.....	.....	1.60	1.67	3.11	1.65	1.72	1.56	1.50
31	.....	.....	1.69	.....	1.68	.....	1.58	1.75	.....	1.77

COLUMBUS STATION ON LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 182, is located near the iron bridge of the Union Pacific Railway, just west of Columbus, Nebraska. The observer is M. Savage, bridge watchman. The gage is 50 yards from the bridge, and is of oak, 3 by 6 inches, 12 feet long, fastened by lag screws to a pile, which forms part of the training works above the bridge. The rod is vertical. The 12-foot mark on the rod is 7 feet below a point 2 feet east of the third panel point of the north truss of the east span, counting the end of the span as the first panel point. Bench mark 2 is the regulation 4-foot iron post of the United States Geological Survey, placed 72 feet east of gage rod. Its elevation is 13.27 feet above zero of gage. The following discharge measurements were made by Adna Dobson and O. V. P. Stout in 1897:

March 19, gage height, 5.22 feet; discharge, 6,307 second-feet.
March 23, gage height, 4.85 feet; discharge, 3,869 second-feet.
April 27, gage height, 4.53 feet; discharge, 2,972 second-feet.
April 27, gage height, 4.53 feet; discharge, 3,103 second-feet.
May 25, gage height, 4.77 feet; discharge, 2,572 second-feet.
May 25, gage height, 4.77 feet; discharge, 2,410 second-feet.
June 17, gage height, 4.72 feet; discharge, 2,818 second-feet.
July 16, gage height, 4.01 feet; discharge, 2,513 second-feet.
July 29, gage height, 3.87 feet; discharge, 1,660 second-feet.
August 17, gage height, 4.27 feet; discharge, 1,783 second-feet.
August 29, gage height, 4.21 feet; discharge, 1,436 second-feet.
October 7, gage height, 4.19 feet; discharge, 1,926 second-feet.
October 30, gage height, 4.70 feet; discharge, 4,580 second-feet.
November 21, gage height, 4.40 feet; discharge, 3,006 second-feet.

Daily gage height, in feet, of Loup River at Columbus, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	5.24	.....	.....	.....	4.46	4.52	7.71	3.89	4.24	4.16
2	.....	.....	7.53	.....	4.44	4.44	5.32	3.85	4.20	4.16
3	.....	.....	.....	5.83	4.52	4.41	4.69	3.81	4.15	4.17
4	.....	.....	.....	.....	4.54	4.80	4.60	3.79	4.15	4.16
5	4.96	.....	7.59	.....	4.56	4.64	4.48	4.02	4.13	4.16
6	.....	.....	.....	.....	4.57	4.78	4.22	4.42	4.09	4.16
7	.....	.....	.....	.....	4.57	4.70	4.02	4.31	4.12	4.17
8	5.18	.....	.....	4.88	4.60	4.68	3.84	4.39	4.03	4.18
9	.....	.....	7.68	4.77	4.62	4.68	3.78	4.71	4.07	4.16
10	.....	.....	.....	4.70	4.69	4.68	3.86	4.70	4.22	4.18
11	.....	.....	.....	4.56	4.63	4.63	3.92	4.81	4.31	4.29
12	7.18	.....	8.45	4.44	4.66	4.70	4.02	4.61	4.36	4.43
13	.....	.....	.....	4.84	4.63	4.77	3.96	4.54	4.36	4.46
14	.....	.....	.....	4.93	4.63	4.75	3.91	4.48	4.34	4.44
15	7.04	.....	.....	4.74	4.66	4.76	4.20	4.40	4.34	4.44
16	.....	.....	5.73	4.70	4.67	4.74	4.08	4.33	4.30	4.50
17	.....	.....	.....	4.77	4.66	4.72	3.92	4.28	4.37	4.58
18	.....	.....	.....	4.91	4.65	4.69	3.84	4.19	4.28	5.00
19	.....	.....	5.43	4.53	4.66	4.82	3.78	4.17	4.25	5.02
20	.....	6.45	.....	4.63	4.62	4.74	3.95	4.15	4.23	4.86
21	.....	.....	.....	4.61	4.64	4.54	4.00	4.15	4.20	4.82
22	.....	.....	.....	4.62	4.77	4.43	3.96	4.15	4.20	4.76
23	.....	6.45	4.85	4.86	4.78	4.35	3.95	4.15	4.21	4.72
24	.....	.....	.....	4.82	4.82	4.34	3.96	4.16	4.24	4.80
25	.....	.....	.....	4.72	4.77	4.34	3.95	4.15	4.26	4.68
26	.....	7.68	4.59	4.66	4.66	4.44	3.98	4.20	4.26	4.64
27	.....	.....	.....	4.54	4.60	4.70	3.93	4.15	4.22	4.81
28	.....	.....	.....	4.41	4.68	4.95	3.85	4.10	4.20	6.26
29	.....	.....	.....	4.40	4.62	4.79	3.85	4.20	4.18	4.80
30	.....	.....	4.76	4.54	4.55	5.00	3.86	4.23	4.16	4.75
31	.....	.....	.....	.....	4.47	.....	3.93	4.28	.....	.....

COLUMBUS STATION ON PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 188, is located on the left bank of the main channel of the river, about 75 feet above the bridge which crosses the channel on the sixth principal meridian near Columbus, Nebraska. The observer is George E. Barnum, a farmer, whose house is about one-half mile from the gage. The gage consists of an inclined oak piece, 3 by 4 inches in section, and 12 feet long. It is fastened to cross-ties, which are bedded, and to stakes which are driven in the bank of the river. The channel is straight both above and below the gage. A round stump on the west side of the road and 80 feet north of the north end of the north truss of the bridge and a square stump directly opposite on the east side of the road were selected as bench marks. The top of the first is 7.38 feet above the zero of the gage, and the top of the second is 7.66 feet above the zero of the gage. Bench mark 3 is the standard 4-foot iron post of the United States Geological Survey and is located 44.5 feet east of gage, 60 feet north of north end of north bridge truss, and 10 feet west of cottonwood tree 6 inches in diameter. Its elevation is 7.06 feet above gage datum. The following discharge measurements were made by Adna Dobson and O. V. P. Stout in 1897:

March 20, gage height, 2.90 feet; discharge, 4,963 second-feet.
April 29, gage height, 3.93 feet; discharge, 8,608 second-feet.
May 5, gage height, 3.79 feet; discharge, 7,322 second-feet.
May 26, gage height, 4.31 feet; discharge, 10,694 second-feet.
June 17, gage height, 4.37 feet; discharge, 12,685 second-feet.
July 11, gage height, 3.05 feet; discharge, 4,001 second-feet.
July 28, gage height, 2.43 feet; discharge, 994 second-feet.
August 17, gage height, 3.18 feet; discharge, 3,343 second-feet.
August 29, gage height, 2.50 feet; discharge, 1,649 second-feet.
October 7, discharge, 2 second-feet.
November 20, gage height, 2.88 feet; discharge, 2,645 second-feet.

Daily gage height, in feet, of Platte River at Columbus, Nebraska, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	4.90	3.90	(a)	(a)	(a)	17	4.30	4.42	2.70	2.70	(a)	(a)
2	.....	4.88	3.90	(a)	(a)	(a)	18	4.40	4.05	(a)	2.80	(a)	(a)
3	.....	4.88	3.82	(a)	(a)	(a)	19	4.40	3.90	(a)	2.80	(a)	(a)
4	3.70	5.15	3.65	(a)	(a)	(a)	20	4.28	3.95	(a)	2.90	(a)	(a)
5	3.75	4.95	3.35	(a)	(a)	(a)	21	4.20	4.20	(a)	2.90	(a)	(a)
6	3.82	4.80	3.18	(a)	(a)	(a)	22	4.20	4.32	(a)	2.90	(a)	(a)
7	3.95	4.80	3.10	(a)	(a)	(a)	23	4.10	4.22	(a)	2.80	(a)	(a)
8	4.10	4.85	3.10	(a)	(a)	(a)	24	4.00	4.18	(a)	2.70	(a)	(a)
9	4.05	4.90	3.10	(a)	(a)	(a)	25	4.15	4.25	(a)	2.60	(a)	(a)
10	4.20	4.95	3.00	(a)	(a)	(a)	26	4.30	4.30	(a)	2.60	(a)	(a)
11	4.15	5.00	2.85	(a)	(a)	(a)	27	4.28	4.30	(a)	2.60	(a)	2.20
12	4.20	5.30	2.70	(a)	(a)	(a)	28	4.48	4.25	(a)	2.60	(a)	2.20
13	4.20	5.20	2.70	(a)	(a)	(a)	29	4.52	4.15	(a)	2.20	(a)	2.25
14	4.20	4.82	2.70	(a)	(a)	(a)	30	4.75	3.95	(a)	2.20	(a)	2.25
15	4.30	4.68	2.70	(a)	(a)	(a)	31	4.90	(a)	(a)	2.20	(a)	(a)
16	4.30	4.58	2.70	(a)	(a)	(a)							

a No water at gage.

NOTE.—August 17 rod found to be loose, and heights subject to change.

NORFOLK STATION ON ELKHORN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 190, is about 2 miles south of Norfolk, Nebraska, near the line of Thirteenth street extended. The gage is on the left bank of the river. It consists of an inclined oak piece, 2 by 4 inches, 12 feet long, resting on beveled blocks which rest in turn on horizontally bedded cross-ties. All are firmly fastened together by lag screws. The zero of the gage s 8.21 feet below a small spike driven horizontally into a tree near the root, about 20 feet back, and downstream from the gage. Also, the zero of the gage is 3.96 feet below the head of a lag screw which is placed vertically in the horizontal trunk of a large living willow tree which overhangs the stream about 15 feet below the gage. Bench mark 3 is a standard 4-foot iron pipe of the United States Geological Survey, located 35 feet west and 7 feet north of top of gage, and 15.5 feet west of ash tree on which is bench mark 1. Its elevation is 10.70 feet above zero of gage. The observer is Burr Taft, a farmer, whose home is about 300 yards from the gage. The river bed at the station is composed of sand and mud. The following measurements of discharge were made by O. V. P. Stout and Adna Dobson, in 1897:

March 24, gage height, 2.72 feet; discharge, 1,323 second-feet.
May 6, gage height, 2.02 feet; discharge, 647 second-feet.
May 24, gage height, 1.38 feet; discharge, 387 second-feet.
June 21, gage height, 1.03 feet; discharge, 270 second-feet.
July 9, gage height, 0.90 foot; discharge, 212 second-feet.
July 30, gage height, 0.78 foot; discharge 200 second-feet.
August 16, gage height, 0.89 foot; discharge 220 second-feet.
September 2, gage height, 0.68 foot; discharge, 163 second-feet.
October 15, gage height, 0.79 foot; discharge, 168 second-feet.

North Fork:

March 24, discharge, 701 second-feet.
May 6, discharge, 166 second-feet.
May 24, discharge, 77 second-feet.
July 30, discharge, 70 second-feet.

Daily gage height, in feet, of Elkhorn River at Norfolk, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	.....	2.41	1.22	1.21	0.70	0.64	0.63
2	2.90	.....	.....	.....	2.30	1.33	1.21	.75	.67	.62
3	.....	.....	.....	4.06	2.22	1.34	1.12	.80	.63	.60
4	.....	.....	.....	5.95	2.15	1.29	1.08	.81	.61	.61
5	.....	.....	.....	.....	2.05	1.26	1.02	.81	.62	.61
6	.....	2.86	3.01	5.66	2.01	1.26	.96	1.00	.58	.64
7	.....	.....	.....	6.43	1.93	1.24	.95	.91	.57	.64
8	.....	.....	.....	6.93	1.93	1.20	.89	1.06	.56	.70
9	2.52	.....	.....	6.62	2.12	1.16	.88	1.06	.50	.67
10	.....	.....	.....	6.27	1.95	1.16	1.21	1.03	.65	.71
11	.....	.....	.....	5.50	1.86	1.15	1.36	.97	.65	.72
12	.....	.....	.....	5.26	1.80	1.12	1.10	.96	.64	.71
13	.....	2.99	.....	4.90	1.78	1.11	1.02	.90	.64	.85
14	.....	.....	.....	4.52	1.74	1.11	1.00	.96	.64	.85
15	.....	.....	.....	4.28	1.73	1.12	.96	.95	.64	.77
16	2.66	.....	.....	4.08	1.66	1.09	.91	.90	.73	.84
17	.....	.....	.....	3.99	1.65	1.16	.89	.81	.79	.94
18	.....	.....	.....	3.98	1.65	1.15	.86	.86	.78	9.71
19	.....	.....	.....	3.89	1.57	.....	.82	.86	.77	1.02
20	.....	4.24	3.42	3.93	1.52	1.11	1.01	.81	.70	1.00
21	.....	.....	.....	3.87	1.48	1.03	1.02	.76	.77	.98
22	.....	.....	.....	3.72	1.47	1.03	.....	.76	.70	.96
23	2.04	.....	.....	3.56	1.47	1.04	.91	.76	.70	.94
24	.....	.....	.....	3.42	1.38	1.03	.90	.74	.76	.91
25	.....	.....	.....	3.26	1.35	1.00	.86	.75	.70	.94
26	.....	.....	.....	3.10	1.34	1.01	.86	.72	.69	.96
27	.....	3.22	2.24	2.94	.....	1.00	.82	.70	.68	.99
28	.....	.....	.....	2.82	1.31	1.01	.81	.71	.64	1.06
29	.....	.....	.....	2.65	1.26	1.07	.76	.67	.66	1.07
30	2.72	.....	.....	2.51	1.24	1.18	.76	.70	.63	1.09
31	.....	.....	.....	.....	1.22	.....	.76	.64	.....	1.12

WESTERN RIVER STATIONS.

The descriptions of the remaining river stations, mainly within the Rocky Mountain Region, and tables of river height, are printed in Water-supply and Irrigation Paper No. 16, since the publications of this series are limited by the act of June 11, 1896, to 100 pages in length. The results of computations of discharge and facts of general interest are prepared for publication in the Nineteenth Annual Report of this survey, these being accompanied by diagrams, maps, and other illustrations, in form similar to the report of progress of stream measurements for the calendar year 1896, printed in the Eighteenth Annual Report, Part IV.

[For index, see Part II of this report—Water-Supply Paper No. 16.]

○

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to The Director, United States Geological Survey, Washington, D. C.

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.

In press:

12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas, by W. F. Hutson, 1898.
14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896-97:

Provided, That hereafter the reports of the Geological Survey in relation to the ganging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved, June 11, 1896; Stat. L., vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Survey is 1,000. This quantity falls far short of the demand, so that it is impossible to supply all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules, or who have furnished data. Requests made for a certain paper and stating a reason for asking for it are granted whenever practicable, but it is impossible to comply with general demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.

55TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 511.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 16

OPERATIONS AT RIVER STATIONS, 1897.—PART II

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

OPERATIONS AT RIVER STATIONS, 1897

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART II

WASHINGTON

GOVERNMENT PRINTING OFFICE

1898

CONTENTS.

	Page.
Introduction	107
Superior station on Republican River	107
Junction City station on Republican River	109
Beloit station on Solomon River	110
Niles station on Solomon River	111
Beverley station on Saline River	112
Salina station on Saline River	113
Ellsworth station on Smoky Hill River	114
Manhattan station on Blue River	115
Lawrence station on Kansas River	116
Granite station on Arkansas River	117
Salida station on Arkansas River	118
Canyon City station on Arkansas River	119
Pueblo station on Arkansas River	120
Nepesta station on Arkansas River	121
Rocky Ford station on Arkansas River	122
Trinidad station on Purgatoire River	123
Hutchinson station on Arkansas River	124
Liberty station on Verdigris River	125
Iola station on Neosho River	126
Del Norte station on Rio Grande	127
Embudo station on Rio Grande	128
Abiquiu station on Chama River	129
Rio Grande station on Rio Grande	130
San Marcial station on Rio Grande	131
El Paso station on Rio Grande	132
Granger station on Blacks Fork	134
Greenriver station on Green River	135
Blake station on Green River	136
Shoshone station on Grand River	137
Grand Junction station on Grand River	137
Fort Crawford station on Uncompahgre River	139
Roubideau and Whitewater stations on Gunnison River	140
Grand Junction station on Gunnison River	141
Fall Creek station on San Miguel River	142
Dolores station on Dolores River	143
Arboles station on San Juan River	144
Arboles station on Piedra River	145
Durango station on Animas River	146
Buttes station on Gila River	147
McDowell station on Salt River	148
McDowell station on Verde River	150
Yuma station on Colorado River	151
Elko station on Humboldt River	152
Battle Mountain station on Humboldt River	153
Golconda station on Humboldt River	154
Oreana station on Humboldt River	155
Mason's Ranch station on South Fork of Humboldt River	156
Battle Creek station on Bear River	157
Logan station on Logan River	158
Collinston station on Bear River	159
Ogden station on Ogden River	160

Page.
Uinta station on Weber River 161
Provo station on Provo River 162
Geneva station on Utah Lake 163
Pocatello station on Portneuf River 164
Montgomery station on Snake River 165
Toponis station on Malad and Little Wood rivers 165
Grandview station on Bruneau River 167
Boise station on Boise River 168
Vale station on Malheur River 169
Payette station on Payette River 170
Weiser station on Weiser River 171
Hooper station on Palouse River 172
Selah station on Yakima River 173
North Yakima station on Naches River 174
Union Gap station on Yakima River 175
Kiona station on Yakima river 176
Spokane station on Spokane River 177
Wenatchee station on Wenatchee River 178
Whitman station on Wallawalla River 179
Gibbon station on Umatilla River 180
Moro station on Deschutes River 181
Tuckers station on Hood River 181
Seguin station on Dungeness River 182
McDonald station on Elwha River 183
Forks station on Calowa River 184
Quillayute station on Solduck River 184
Jellys Ferry station on Sacramento River 185
Redbluff station 185
Oakdale station on Stanislaus River 187
Lagrange station on Tuolumne River 188
Modesto station on Tuolomne River 189
Herndon station on San Joaquin River 190
Red Mountain station on Kings River 191
Kingsburg station on Kings River 192
Palmdale station on Little Rock Creek 193
Azusa station on San Gabriel River 194
Warm Springs station on Santa Ana River 195
Index to Water-Supply Papers Nos. 15 and 16 197

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, February 15, 1898.

SIR: I have the honor to transmit herewith brief descriptions of the river stations at which work was carried on by the Division of Hydrography of this Survey during 1897, together with tables of daily height.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

OPERATIONS AT RIVER STATIONS, 1897.

INTRODUCTION.

Descriptions of river stations in the eastern part of the United States and those on the headwaters of the Missouri and Platte rivers are given in paper No. 15 of this series. The results of the computations of discharge, together with diagrams, maps, and other illustrations, are prepared for publication in the Nineteenth Annual Report of this Survey, in form similar to the results for 1896, given in the Eighteenth Annual Report, Part IV, pp. 1–418. The descriptions of operations at river stations, with accompanying tables of daily gage heights, are printed in this series of Water-Supply and Irrigation Papers in order that the results may be available at as early a date as possible, the preparation and printing of the necessary illustrations for the annual report requiring much time. In order to print these descriptions in this series of papers it has been found necessary to divide them into two parts, as by the act of June 11, 1896 (Stat. L., Vol. XXIX, p. 453), the papers can not exceed 100 pages in length.

The subject-matter of this and the preceding paper has been so arranged as to follow the general geographic order of the drainage basins, beginning at the extreme east and extending southerly along the Atlantic slope, then taking up the headwaters of the Ohio, next the upper Missouri and its great tributary the Platte. This material has been found to occupy the prescribed limit of 100 pages of paper No. 15. In the present paper (No. 16), the stations on the Republican River and other tributaries of Kansas River are taken up; then those on the Arkansas River, Rio Grande, and the tributaries of the great Colorado River west; next the stations on the rivers of the great interior basin; then those on the streams flowing into Columbia River; and finally the stations in California.

SUPERIOR STATION ON REPUBLICAN RIVER.

This station, described in the Eighteenth Annual Report of the United States Geological Survey, Part IV, page 199, is located about 1 mile west of Superior, Nebraska. It is on the left bank of the river, about 25 feet above the iron highway bridge. A dam and the head of a mill race are only a short distance below the bridge. The observer is

T. C. Sheffer. The gage consists of an oak piece 2 by 4 inches, 10 feet long. The face is inclined 30 degrees to the horizontal, and the foot-marks are placed 2 feet apart to correspond to this inclination. The rod is fastened to cross-ties which are bedded in the bank of the river. The location is on the outside of an easy bend in the river. The bed of the river is of mud and sand. The top of the rim of the upstream cylinder of the north pier is 15.42 feet above zero of the gage. Bench mark 2 is the standard 4-foot iron pipe of the United States Geological Survey. It is 83 feet north of the upstream cylinder of the north pier of the bridge and is 10 feet west of the line of the upstream truss of the bridge. It is 1 foot inside a wire fence. The top of the pipe is 4 inches above the ground and the elevation is 4.88 feet above gage datum. The following measurements were made in 1897 by Adna Dobson and O. V. P. Stout:

April 12, gage height, 1.12 feet; discharge, 1,257 second-feet.
April 24, gage height, 0.99 foot; discharge, 887 second-feet.
May 18, gage height, 0.45 foot; discharge, 337 second-feet.
June 12, gage height, 0.72 foot; discharge, 716 second-feet.
July 8, gage height, 0.87 foot; discharge, 766 second-feet.
July 18, gage height, 0.32 foot; discharge, 222 second-feet.
August 6, gage height, 0.49 foot; discharge, 372 second-feet.
August 22, gage height, — 0.05 foot; discharge, 195 second-feet.
September 25, gage height, 0.04 foot; discharge, 81 second-feet.
October 24, gage height, 0.02 foot; discharge, 184 second-feet.

Daily gage height, in feet, of Republican River at Superior, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.01	.....	.....	0.87	0.28	1.48	0.08	0.12	—0.12
2	0.75	1.01	0.84	0.97	.77	.27	.75	.12	.06	— .34
3	.80	1.01	.....	.....	.69	.32	1.65	.08	.01	.00
4	.80	1.01	.....	1.00	.67	.32	1.39	.07	— .06	— .35
5	.80	1.01	.....	1.67	.64	.27	1.35	.12	+ .04	— .30
6	.80	1.01	.70	1.50	.66	.36	2.15	.48	.03	— .58
7	.80	1.01	.70	1.05	.63	.54	1.64	.20	.01	— .30
8	.80	1.01	.....	1.18	.60	.40	1.80	.57	— .20	— .52
9	.80	1.01	.....	1.12	.77	.34	1.48	.56	— .25	— .71
10	.80	1.01	.64	1.08	.80	.31	1.06	.45	— .16	— .50
11	.80	1.01	.....	1.09	.66	.92	.94	.45	— .02	— .35
12	.80	1.01	.....	1.12	.62	.74	.70	.56	+ .20	— .30
13	.80	1.01	.....	1.14	.60	.54	.51	.54	.60	— .53
14	.80	.....	.....	1.07	.54	.71	.39	.55	.00	— .58
15	.80	1.01	.71	1.09	.52	.48	.34	.10	.01	— .90
16	.80	.....	.....	1.62	.50	.76	.28	.14	.36	+ .04
17	.....	.....	.55	1.31	.48	.79	.28	.14	.26	1.22
18	.....	.....	.....	1.14	.45	.74	.32	.18	.26	1.30
19	.....	1.00	.....	1.08	.42	.66	.25	.21	.15	1.25
20	.90	.....	.61	1.05	.38	.68	.34	.31	.10	1.19
21	.....	.60	.....	1.03	.35	.58	.30	.24	.05	1.11
22	.....	.....	.86	1.02	.37	.47	.22	.30	.04	1.10
23	1.01	.....	.65	.92	1.10	.43	.66	.27	— .05	1.11
24	1.01	.....	.....	1.00	.63	.48	.69	.57	+ .01	— .05
25	1.01	1.22	.....	.98	.61	.33	.15	.50	.02	+1.06
26	1.01	.....	.....	.88	.57	2.42	.23	.39	— .35	1.08
27	1.01	.....	.64	.82	.63	4.38	.16	.31	— .12	2.45
28	1.01	.....	.....	1.32	.42	1.87	.84	.26	— .09	2.32
29	1.01	.....	.....	1.20	.40	1.78	.30	.23	— .06	1.53
30	1.01	.....	.....	.98	.32	1.72	.17	.14	— .05	1.45
31	1.01	.....	.81	.....	.27	.....	.14	.11	.....	.....

JUNCTION CITY STATION ON REPUBLICAN RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 203, is located at the wagon bridge at the north end of Washington street, Junction City, Kansas. The observer is John Davis. The gage consists of two oak timbers bolted to a post and to a cottonwood tree. One bench mark consists of a 60-penny nail driven into the base of the abutment at an elevation of 10.67 feet on the scale. A second bench mark is the top of the stone in the base of the bridge abutment, 18 feet south of the gage; its elevation is 14.51 feet. A subsidiary gage for determining the slope has been placed 507 feet upstream, and referred to the same datum. The right bank is high, but the left is low and may overflow in high water. The bed of the stream is sandy and changeable. The following are the discharge measurements made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 23...	4.30	1,021	May 21....	3.10	725	July 28 ..	4.45	1,367
Mar. 23...	3.80	611	June 1	3.70	869	Aug. 18 ..	4.20	1,243
Apr. 7	4.30	1,015	June 16 ...	6.30	3,637	Sept. 30..	2.30	175
Apr. 20...	4.90	1,433	June 30 ...	7.40	6,053	Oct. 26...	2.80	313
Apr. 27...	6.10	3,565	July 13....	5.95	3,141	Nov. 12 ..	3.50	616
May 6....	3.60	1,078						

Daily gage height, in feet, of Republican River at Junction City, Kansas for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	3.40	3.80	4.00	4.40	3.65	6.15	2.95	2.75	2.30	4.15	2.70
2	3.80	3.40	3.70	4.00	4.40	3.35	6.50	3.45	2.60	2.30	3.60	2.80
3	3.95	3.55	3.65	4.00	4.35	3.15	6.40	3.00	2.55	2.30	3.40	3.10
4	3.80	3.85	3.95	4.05	4.20	3.05	5.65	2.85	2.50	2.20	3.30	3.20
5	3.80	4.00	4.05	4.10	3.95	2.95	5.05	3.40	2.50	2.20	3.35	3.30
6	3.70	4.05	3.85	4.15	3.70	2.85	4.90	3.60	2.50	2.20	3.40	3.30
7	3.70	4.15	3.80	4.25	3.50	2.80	4.70	3.05	2.50	2.20	3.40	3.30
8	3.60	4.15	3.85	4.55	3.50	2.80	4.50	2.85	2.35	2.20	3.40	3.30
9	3.65	4.20	4.20	4.60	3.40	2.70	4.65	2.75	2.30	2.20	3.50	3.40
10	3.55	4.25	4.05	4.70	3.35	2.70	7.05	2.70	2.35	2.20	3.50	3.50
11	3.45	4.25	3.90	4.60	3.55	2.70	7.50	2.85	2.50	2.20	3.50	3.40
12	3.45	4.20	3.90	4.70	3.55	2.90	7.25	3.60	2.30	2.20	3.50	3.45
13	3.50	4.55	3.90	4.60	3.40	4.55	5.80	3.35	2.30	2.20	3.50	3.55
14	3.55	4.85	3.80	4.45	3.45	6.25	5.00	3.55	2.30	2.15	3.50	3.50
15	3.35	4.80	3.70	4.45	3.55	5.60	4.30	4.80	2.30	2.10	3.45	3.50
16	3.45	4.80	3.70	4.45	3.60	6.15	3.90	5.25	2.30	2.20	3.40	3.60
17	3.60	5.00	3.60	4.45	3.50	5.70	3.65	5.00	2.30	2.40	3.40	3.60
18	3.60	5.85	3.80	4.40	3.40	6.05	3.45	4.15	2.30	2.40	3.40	3.60
19	3.50	5.20	3.85	4.40	3.35	5.70	3.30	4.35	2.30	2.40	3.40	3.60
20	3.65	5.15	3.90	4.80	3.15	4.90	3.15	3.30	2.30	2.55	3.40	3.50
21	3.60	4.80	3.80	4.80	3.10	5.00	3.05	3.00	3.05	2.85	3.40	3.40
22	3.70	4.35	3.75	4.65	3.05	4.35	3.25	2.85	3.25	3.00	3.40	3.50
23	4.20	4.20	3.75	4.55	2.95	4.05	3.30	2.70	3.05	3.00	3.40	3.50
24	3.50	4.30	3.75	7.20	2.80	4.55	3.05	2.70	2.75	3.00	3.35	3.50
25	3.50	4.20	3.70	7.95	2.80	5.25	3.20	2.65	2.60	2.90	3.30	3.60
26	3.50	4.40	3.90	7.35	2.80	5.10	3.30	2.60	2.50	2.80	3.40	3.55
27	3.40	4.10	3.90	6.20	3.55	3.95	3.35	2.60	2.40	2.90	3.40	3.65
28	3.40	3.85	3.90	5.70	4.55	3.80	4.40	2.60	2.40	2.80	3.35	3.80
29	3.35	.....	3.90	5.05	5.50	5.70	3.90	2.85	2.35	2.80	2.85	3.90
30	3.30	.....	3.90	4.70	4.75	7.40	3.40	2.90	2.30	2.80	2.70	3.80
31	3.30	.....	3.90	.....	4.15	.....	3.15	2.80	.....	2.90	.....	3.80

BELOIT STATION ON SOLOMON RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 207, is located at the wagon bridge on the south edge of the town of Beloit, Kansas. The observer is W. F. Jordon. The rod of the wire gage is a spruce board, 12 feet long, graduated in feet and tenths, spiked to the upstream edge of the bridge floor, over the deepest water. The bench mark consists of a tenpenny nail driven into the base of a cottonwood tree 35 feet northwest of the pier upon which the marks are made. Its elevation is 13.70 feet. Measurements were made from the bridge, the initial point being at the south edge of the stone abutment on the left bank of the stream. This station was discontinued on June 30, 1897, as a more favorable location was found at Niles, and a station was therefore established at the latter place. The following discharge measurements were made in 1897 by W. G. Russell:

February 23, gage height, 3.50 feet; discharge, 102 second-feet.
March 23, gage height, 2.70 feet; discharge, 24 second-feet.
April 7, gage height, 4.20 feet; discharge, 508 second-feet.
April 20, gage height, 3.55 feet; discharge, 247 second-feet.
April 28, gage height, 3.40 feet; discharge, 270 second-feet.
May 20, gage height, 3.10 feet; discharge, 197 second-feet.
June 15, gage height, 7.80 feet; discharge, 2,565 second-feet.

Daily gage height, in feet, of Solomon River at Beloit, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	3.20	3.25	3.65	3.65	3.70	2.55	17.....	2.80	3.65	3.35	3.45	3.15	15.00
2....	3.20	2.95	3.45	3.60	3.55	2.75	18.....	3.40	3.90	3.60	3.30	3.15	5.20
3....	2.45	3.40	3.45	3.70	3.45	3.00	19.....	3.45	3.60	3.35	3.50	3.05	3.90
4....	3.10	2.60	3.65	5.30	3.45	2.75	20.....	3.45	3.55	3.60	3.35	3.00	3.65
5....	2.40	3.40	3.65	4.70	3.30	2.90	21.....	3.40	3.15	3.10	3.60	3.05	3.65
6....	3.15	3.40	3.70	4.55	3.25	2.60	22.....	3.40	3.50	3.60	3.60	2.90	4.00
7....	2.85	2.60	3.10	4.05	3.25	2.65	23.....	3.40	3.45	3.15	3.60	2.90	8.05
8....	3.05	3.40	3.40	3.90	3.40	2.75	24.....	2.95	3.45	3.45	7.10	3.65	4.00
9....	3.05	3.35	3.65	4.45	3.05	2.70	25.....	2.95	3.45	3.60	8.90	3.85	6.00
10....	2.85	3.35	3.35	4.20	3.20	2.75	26.....	3.45	3.40	3.05	8.55	3.20	3.90
11....	3.40	3.45	3.50	4.05	3.30	4.85	27.....	3.35	3.50	3.50	3.50	3,00	14.75
12....	3.10	3.55	3.45	4.05	3.55	11.55	28.....	3.40	2.60	3.25	3.45	2.50	22.35
13....	3.30	3.40	3.45	3.80	3.30	6.70	29.....	2.90	.....	3.70	3.65	3.00	19.45
14....	2.75	3.00	3.10	3.65	3.25	3.55	30.....	3.35	.....	3.65	3.95	2.60	5.25
15....	3.20	3.40	3.35	3.65	3.10	12.10	31.....	2.55	.....	3.65	.....	3.00	.....
16....	3.40	3.45	3.45	3.40	3.10	23.25							

NILES STATION ON SOLOMON RIVER.

This station is located at a bridge one-half mile west of Niles, Kansas, and was established May 5, 1897. The rod of the wire gage is spiked to the floor of the bridge. It is 1 by 4 inches by 24 feet long. The bench mark is the upper one of three nails driven into a cottonwood tree 18 inches in diameter, north side of the river and 25 feet east of the bridge. Its elevation is 24.96 feet above gage datum. The initial point for soundings is on the right bank. The channel is straight for about 100 feet above and below the section. The current is sluggish. The right bank is high, and the left bank overflows only in very high water. The bed of the stream is muddy. The observer is J. J. Little. The following discharge measurements were made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
May 5....	6.60	386	June 17 ...	13.55	2,083	July 28 ..	5.80	193
May 20...	5.70	253	June 18 ...	16.95	3,159	Aug. 18 ..	5.60	193
June 1 ...	5.30	179	June 18 ...	18.25	3,701	Sept. 30 ..	4.80	95
June 15 ..	13.60	1,898	July 1.....	20.70	4,856	Oct. 25...	4.50	83
June 16 ..	9.40	974	July 13....	7.55	451	Nov. 12 ..	4.80	96

Daily gage height, in feet, of Solomon River at Niles, Kansas, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.35	20.95	6.40	4.80	4.80	4.90	5.30
2	.....	5.20	21.17	6.15	4.95	4.70	4.85	5.15
3	.....	5.15	13.35	5.95	4.95	4.55	4.80	5.15
4	.....	5.15	8.95	5.80	4.80	4.50	5.25	5.20
5	.....	5.20	9.00	5.70	4.85	4.30	5.15	5.20
6	6.45	5.15	8.55	6.05	4.85	4.75	5.10	5.25
7	6.10	5.10	7.80	5.75	4.75	4.65	5.15	5.15
8	6.02	5.05	7.35	5.50	4.75	4.50	5.00	5.15
9	6.05	5.10	7.10	5.35	4.65	4.60	4.85	5.20
10	6.20	5.10	8.95	5.65	4.60	4.55	4.90	5.25
11	6.35	5.05	10.40	5.45	4.60	4.80	5.00	5.20
12	5.80	4.80	9.80	5.35	4.65	4.35	4.95	5.30
13	6.05	4.80	7.85	5.50	4.55	4.80	4.85	.....
14	6.15	9.70	7.45	5.40	4.50	4.65	4.95	.....
15	6.50	13.50	8.05	5.80	4.55	4.65	4.60	.....
16	6.05	8.80	7.10	6.20	4.90	4.55	4.60	.....
17	6.00	10.90	6.60	5.90	4.70	4.70	4.80	.....
18	5.85	17.45	6.35	5.65	4.55	4.65	4.90	5.00
19	5.85	20.00	6.25	5.65	4.40	4.55	4.90	5.00
20	5.80	17.85	6.20	5.60	4.60	5.10	4.95	.....
21	5.60	9.25	6.05	5.40	4.45	5.15	5.00	.....
22	5.55	8.65	6.10	5.35	5.05	4.90	4.85	.....
23	5.45	7.70	5.90	5.30	5.60	4.80	4.80	.....
24	5.30	8.70	5.80	5.20	5.40	4.70	4.80	.....
25	5.30	11.25	5.70	5.20	5.25	4.75	4.90	5.30
26	5.35	13.50	5.85	5.25	5.10	4.75	4.75	5.30
27	6.70	11.10	5.85	5.15	4.90	4.75	4.90	.....
28	8.30	9.15	5.90	5.05	4.95	4.90	4.95	.....
29	6.50	12.90	6.95	4.95	4.75	5.05	4.60	.....
30	5.85	18.50	8.00	4.85	4.80	4.95	4.90	.....
31	5.55	.....	7.00	.....	.....	4.95	.....	5.30

BEVERLY STATION ON SALINE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 210, is located at the iron highway bridge one-half mile southwest of Beverly, Kansas. The observer is Jerome Wilson, who lives about one-half mile from the station. The gage is an inclined timber, fastened to trestles which are set in the ground and well loaded down with rock. It is graduated up to 18 feet, and one of the iron cylinder bridge piers is then graduated up to 30 feet. The bench mark is the top of the lower iron strut at the north end connecting the two south piers. Its elevation is 18.95 feet above the zero of the gage. This station was discontinued on June 30, 1897, as a more favorable location was found at Salina, and a station was therefore established at the latter place. The following measurements of discharge were made in 1897 by W. G. Russell:

February 24, gage height, 4.70 feet; discharge, 67 second-feet.
March 26, gage height, 4.60 feet; discharge, 53 second-feet.
April 15, gage height, 5.40 feet; discharge, 161 second-feet.
April 30, gage height, 5.80 feet; discharge, 196 second-feet.
June 2, gage height, 4.80 feet; discharge, 75 second-feet.

Daily gage height, in feet, of Saline River at Beverly, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	4.45	.....	4.40	4.65	7.05	4.80	17.....	4.75	4.95	4.60	5.25	5.20	4.45
2....	4.55	4.20	4.60	4.55	7.05	4.70	18.....	4.35	5.15	4.50	5.15	5.15	4.45
3....	4.80	.....	4.70	4.55	6.20	4.75	19.....	4.75	4.95	4.55	5.10	5.10	4.65
4....	4.35	4.30	4.70	4.65	5.95	4.60	20.....	4.60	4.85	4.35	5.05	5.05	4.50
5....	4.25	.....	4.20	7.85	5.75	4.75	21.....	4.75	4.75	4.45	5.05	5.00	4.45
6....	4.45	4.40	4.55	8.80	5.65	4.75	22.....	4.70	4.70	4.30	5.00	4.95	4.55
7....	4.35	.....	4.50	6.40	5.55	4.70	23.....	4.70	4.75	4.60	5.00	4.90	4.55
8....	4.20	.....	4.65	5.95	5.55	4.60	24.....	4.60	4.55	4.45	6.00	4.90	4.40
9....	4.55	.....	4.60	5.95	5.50	4.75	25.....	4.60	4.65	4.45	7.20	4.85	4.40
10....	4.35	4.40	4.55	6.50	5.45	4.50	26.....	3.90	4.70	4.45	5.35	4.85	4.45
11....	4.50	5.00	4.50	6.65	5.50	4.55	27.....	3.90	4.75	4.45	5.45	4.85	7.70
12....	4.70	4.70	4.65	6.10	5.45	4.60	28.....	3.90	4.50	4.50	5.45	4.80	17.50
13....	4.60	5.30	4.50	5.75	5.50	4.50	29.....	4.20	.....	4.40	5.45	4.70	7.85
14....	5.05	6.15	4.50	5.55	5.50	4.55	30.....	4.20	.....	4.40	5.80	4.70	5.35
15....	4.60	5.40	4.35	5.45	5.50	4.55	31.....	4.30	.....	4.70	.....	4.60	.....
16....	4.65	5.00	4.35	5.35	5.25	4.55							

SALINA STATION ON SALINE RIVER.

This station is located at a bridge 4.5 miles northeast of Salina, Kansas. The rod of the wire gage is spiked to the floor of the bridge. It is 1 by 4 inches, and 24 feet long. Bench mark 1 is a nail in an elm 2 feet in diameter, on the north side of the river and 6 feet west of the bridge, and its elevation is 22.90 feet above gage datum. Bench mark 2 is six nails driven into a 16-inch box elder on north side of river and 35 feet east of the bridge. Its elevation is 22.90 feet above datum. The channel is straight for a little distance above and below the station. Both banks are high, and are not liable to overflow. The bed of the stream is sandy and muddy. The observer is H. W. Barr. The following discharge measurements were made during 1897 by W. G. Russell:

May 4, gage height, 7.00 feet; discharge, 333 second-feet.
May 17, gage height, 4.90 feet; discharge, 135 second-feet.
May 31, gage height, 3.90 feet; discharge, 73 second-feet.
June 18, gage height, 3.50 feet; discharge, 60 second-feet.
June 28, gage height, 3.20 feet; discharge, 45 second-feet.
July 14, gage height, 3.40 feet; discharge, 54 second-feet.
July 26, gage height, 3.30 feet; discharge, 51 second-feet.
August 19, gage height, 4.90 feet; discharge, 152 second-feet.
September 28, gage height, 2.80 feet; discharge, 26 second-feet.
October 20, gage height, 2.50 feet; discharge, 17 second-feet.
November 11, gage height, 2.90 feet; discharge, 29 second-feet.

Daily gage height, in feet, of Saline River at Salina, Kansas, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.70	9.50	3.00	3.10	2.50	3.15	3.15
2	.....	3.70	5.10	3.05	3.05	2.45	3.15	3.05
3	.....	3.75	4.40	3.15	3.00	2.60	2.85	3.10
4	7.00	3.75	4.10	3.25	3.05	2.60	3.10	3.15
5	6.35	3.65	3.90	3.05	3.10	2.60	2.80	3.10
6	5.90	3.80	3.85	3.05	3.05	2.50	2.85	3.20
7	5.65	3.60	3.70	3.05	3.00	2.50	3.00	3.05
8	5.40	3.75	3.70	3.05	3.00	2.50	2.95	3.15
9	5.30	3.75	3.60	2.95	2.95	2.45	3.10	3.15
10	5.25	3.75	3.75	2.85	2.85	2.55	3.00	3.15
11	5.15	3.75	3.95	3.05	2.80	2.75	3.05	2.85
12	5.10	3.70	3.85	3.15	2.75	2.80	3.15	2.95
13	5.15	3.50	3.70	3.10	2.65	2.70	3.05	3.20
14	5.10	3.55	3.45	3.30	2.65	2.55	2.95	3.25
15	5.05	3.55	3.35	3.45	2.65	2.55	3.05	3.15
16	5.00	3.50	3.40	3.40	2.85	2.65	2.95	3.15
17	4.90	3.55	3.35	7.35	3.45	2.90	3.05	(a)
18	4.55	3.55	3.45	6.75	2.95	2.80	2.95	.....
19	4.70	3.50	3.25	4.80	2.90	2.65	3.05	.....
20	4.65	3.45	3.20	4.15	2.90	2.65	3.10	3.10
21	4.50	3.45	3.80	3.85	2.85	3.35	3.10	.....
22	4.45	3.45	3.40	3.90	2.75	3.70	3.05	.....
23	4.35	3.45	3.10	4.00	2.80	3.50	3.10	.....
24	4.25	3.30	3.00	3.80	2.85	3.55	3.05	3.10
25	4.25	3.50	3.00	3.50	2.75	3.60	3.10	.....
26	4.10	3.55	3.20	3.50	2.90	3.40	3.05	.....
27	4.05	3.35	3.15	3.50	2.75	3.45	3.25	.....
28	4.10	3.30	3.00	3.35	2.75	3.45	3.15	3.20
29	4.05	11.15	3.05	3.30	2.75	3.10	3.15	.....
30	3.90	14.90	3.00	3.30	2.70	3.05	3.20	.....
31	3.85	.....	3.05	3.10	.....	3.15	.....	3.20

a Frozen.

ELLSWORTH STATION ON SMOKY HILL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 212, is located at the highway bridge on Douglas avenue, Ellsworth, Kansas. The observer is Robert Martin, who lives about 100 yards north of the bridge. The gage is an inclined ash timber spiked to a post driven in the bed of the river and bolted to an iron post of the bridge pier. The bench mark is a nail driven in the base of a large box-elder tree near the southeast corner of the bridge, 90 feet from the gage, and its elevation is 13.07 feet above the zero. A slope gage is spiked to the Frisco railroad bridge 2,536 feet upstream and is referred to same datum. The channel is nearly straight above and below the bridge, and the bed is sandy and shifting. The following discharge measurements were made by W. G. Russell in 1897.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 26...	1.30	40	May 17....	1.80	167	Aug. 17...	1.60	84
Mar. 29...	1.15	30	June 4	1.30	57	Aug. 24...	2.30	301
Apr. 6....	2.30	287	June 28 ...	1.40	79	Sept. 24 ..	1.25	57
Apr. 23...	1.45	80	July 15....	1.30	43	Oct. 19 ...	1.40	77
May 8....	1.70	141	July 26....	1.20	38	Nov. 9....	1.30	49

Daily gage height, in feet, of Smoky Hill River at Ellsworth, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.40	1.40	1.20	2.60	1.40	1.35	1.38	1.45	1.00	1.10	1.20
2	1.10	1.40	1.30	1.25	2.35	1.35	1.30	1.45	1.40	1.00	1.20	1.10
3	1.30	1.45	1.20	1.35	2.25	1.30	1.25	1.30	1.35	1.00	1.30	1.10
4	1.35	1.50	1.30	2.10	2.05	1.30	1.20	1.20	1.30	.95	1.40	1.10
5	1.20	1.50	1.30	2.60	1.85	1.30	1.20	1.20	1.25	.95	1.35	1.10
6	1.20	1.55	1.30	2.30	1.80	1.30	1.15	1.15	1.20	.95	1.35	1.10
7	1.25	1.70	1.30	2.15	1.70	1.30	1.10	1.20	1.15	.90	1.35	1.10
8	1.35	1.65	1.30	2.15	1.65	1.40	1.10	1.15	1.10	.90	1.30	1.15
9	1.45	1.60	1.25	2.15	1.70	1.30	1.05	1.10	1.10	.90	1.30	1.15
10	1.40	2.00	1.25	2.15	1.65	1.30	1.20	1.10	1.10	.90	1.30	1.15
11	1.40	1.85	1.20	2.05	1.85	1.30	1.20	1.00	1.10	.90	1.25	1.20
12	1.45	1.55	1.20	1.95	2.10	1.25	1.15	1.00	1.05	.90	1.25	1.20
13	1.30	2.00	1.15	1.80	2.20	1.20	1.15	1.15	1.00	.90	1.25	1.15
14	1.75	1.85	1.15	1.70	2.15	1.20	1.10	1.45	1.00	.90	1.25	1.10
15	1.60	1.75	1.15	1.65	2.05	1.20	1.20	1.80	1.05	.90	1.20	1.15
16	1.25	1.65	1.15	1.60	1.85	1.50	1.25	1.70	1.65	1.00	1.15	1.15
17	1.35	1.95	1.20	1.60	1.75	2.10	1.20	1.60	1.25	1.50	1.15	1.05
18	1.25	2.00	1.20	1.55	1.70	2.10	1.20	1.50	1.20	1.45	1.15	1.10
19	1.40	1.85	1.15	1.50	1.60	1.85	1.15	1.40	1.15	1.40	1.20	1.20
20	1.40	1.70	1.15	1.50	1.50	1.80	1.23	1.30	1.25	1.40	1.20	1.20
21	1.40	1.55	1.10	1.45	1.50	1.70	1.13	1.20	1.40	1.35	1.20	1.20
22	1.45	1.40	1.10	1.45	1.60	1.55	1.10	1.15	1.35	1.30	1.20	1.20
23	1.55	1.45	1.10	1.45	2.15	1.45	1.05	2.15	1.30	1.30	1.15	1.20
24	1.35	1.40	1.10	1.50	1.95	1.40	1.15	2.30	1.25	1.25	1.20	1.20
25	1.35	1.40	1.10	1.55	1.75	1.50	1.25	2.15	1.20	1.25	1.15	1.20
26	1.30	1.35	1.10	1.50	1.60	1.50	1.20	1.95	1.15	1.25	1.10	1.25
27	1.35	1.20	1.10	1.55	1.55	1.45	1.20	1.85	1.10	1.25	1.00	1.35
28	1.35	1.35	1.10	1.60	1.50	1.40	1.25	1.75	1.10	1.20	1.00	1.35
29	1.35	.....	1.15	1.85	1.50	1.35	1.35	1.65	1.05	1.15	1.00	1.40
30	1.40	.....	1.15	2.30	1.50	1.30	1.50	1.60	1.00	1.15	1.00	1.45
31	1.40	.....	1.20	.....	1.45	.....	1.45	1.53	.....	1.10	.....	1.55

MANHATTAN STATION ON BLUE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 215, is located at the county bridge 4 miles north of Manhattan, Kansas. The gage consists of three sections, the lower being an ash stick driven into the bottom of the river and bolted to an overhanging cottonwood tree 30 feet east of the bridge, and marked from 2.10 to 11.30 feet. The middle section consists of an oak stick bolted to the north side of the south bridge pier and marked from 11.30 to 17 feet. A similar stick on the south side of the same pier, and marked from 17 to 30 feet, completes the gage. The bench mark is a cross cut in the capstone of the south bridge pier immediately above the upper gage, and is 32.135 feet above datum. The observer is William Hudspeth. The following discharge measurements were made in 1897 by O. P. Hood and S. R. Vincent:

April 26, gage height, 25.45 feet; discharge, 31,942 second-feet.
April 30, gage height, 10.80 feet; discharge, 5,972 second-feet.
October 30, gage height, 4.00 feet; discharge, 602 second-feet.
December 8, gage height, 4.20 feet; discharge, 499 second-feet.

Daily gage height, in feet, of Blue River at Manhattan, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.00	5.40	6.00	8.75	9.70	6.75	8.75	5.20	4.90	3.55	4.00	4.40
2	4.10	5.10	6.00	16.50	10.30	6.55	7.90	5.05	4.65	3.50	4.00	4.30
3	4.10	5.00	5.80	17.25	9.95	6.40	7.25	4.90	4.55	3.50	3.80	4.25
4	4.25	4.90	5.70	11.50	9.15	6.25	7.00	4.00	4.35	3.40	3.70	4.20
5	4.60	4.55	5.55	10.90	7.95	5.90	6.80	4.70	4.25	3.40	3.80	4.10
6	4.80	4.35	5.00	10.30	7.80	5.70	6.50	5.35	4.05	3.40	3.90	4.10
7	4.90	4.25	4.80	9.75	7.60	5.60	6.20	6.15	3.80	3.30	4.00	4.00
8	4.85	4.00	4.75	8.75	7.50	5.50	6.00	8.85	3.70	3.30	4.00	4.20
9	4.80	4.05	4.65	8.20	7.25	5.40	7.50	8.55	3.60	3.20	4.10	4.30
10	4.60	4.25	5.10	7.90	6.85	5.00	8.35	7.50	3.50	3.20	4.25	4.25
11	4.60	4.35	5.30	7.40	6.75	4.75	10.40	7.15	3.30	3.15	4.25	4.20
12	4.80	4.50	5.45	7.10	6.75	4.55	12.75	6.25	2.50	3.05	4.25	4.25
13	4.85	4.90	5.65	6.90	7.05	4.50	12.25	6.00	2.30	3.00	4.40	4.30
14	4.90	5.65	6.60	6.70	7.10	4.80	9.65	5.75	2.30	3.00	4.50	4.15
15	4.80	5.90	7.15	6.40	6.85	4.95	9.00	6.90	2.75	3.65	4.45	4.00
16	4.75	6.00	6.85	6.00	6.75	5.40	8.50	8.10	3.35	4.00	4.35	4.00
17	4.70	6.25	6.65	5.75	6.35	5.60	8.10	7.90	3.75	4.15	4.30	4.10
18	4.80	6.80	6.35	5.60	6.20	5.90	7.90	7.50	3.85	4.25	4.20	4.15
19	4.85	7.20	6.10	5.50	6.10	6.20	7.10	7.35	4.25	4.35	4.20	4.20
20	4.90	6.65	5.80	5.45	6.00	8.90	6.10	7.05	4.60	4.40	4.10	4.20
21	5.15	6.30	5.75	5.40	5.90	8.75	5.70	6.65	4.50	4.80	4.05	4.35
22	5.00	6.10	5.65	5.50	5.80	8.00	5.55	6.45	4.30	4.25	4.00	4.50
23	4.95	6.00	5.60	9.25	5.75	7.50	5.20	6.35	4.25	4.20	4.05	4.50
24	4.85	5.90	5.50	20.95	5.95	7.00	5.00	6.30	4.15	4.40	4.20	4.60
25	4.80	5.75	5.40	24.15	5.80	7.70	7.20	6.15	4.00	4.30	4.25	4.60
26	5.50	5.65	5.35	25.30	5.85	7.00	6.90	6.05	4.00	4.25	4.30	4.60
27	5.50	5.50	5.30	25.60	6.70	14.55	6.65	5.75	3.90	4.20	4.40	4.60
28	5.50	5.80	6.25	19.65	7.85	19.45	6.10	5.60	3.85	4.30	4.40	4.55
29	5.50	.....	6.85	12.00	7.60	13.40	5.90	5.40	3.80	4.35	4.50	4.40
30	5.55	.....	6.95	10.75	6.80	9.80	5.55	5.25	3.60	4.40	4.50	4.40
31	5.60	.....	7.15	.....	6.85	.....	5.40	5.05	.....	4.40	.....	4.50

LAWRENCE STATION ON KANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 219, is located at Lawrence, Kansas. The gage consists of a vertical board marked to feet and tenths and fastened to the south pier of the carriage bridge, about 50 feet up the river from the crest of a dam. The zero of the gage is on a level with a large stone in the crest of dam. There is also a short vertical board fastened by the side of this one for reading the level of the water when it stands below the zero of the gage. The channel is about 690 feet wide, broken by four piers. The observer is J. D. Bowersock. The following is a list of discharge measurements made in 1897 by E. C. Murphy:

April 9, gage height, 2.55 feet; discharge, 10,238 second-feet.
April 10, gage height, 2.55 feet; discharge, 9,658 second-feet.
April 26, gage height, 9.10 feet; discharge, 60,854 second-feet.
June 17, gage height, 1.50 feet; discharge, 4,820 second-feet.
June 23, gage height, 2.73 feet; discharge, 10,635 second-feet.
June 25, gage height, 2.10 feet; discharge, 8,011 second-feet.

Daily gage height, in feet, of Kansas River at Lawrence, Kansas, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	0.80	1.20	2.65	3.60	1.90	5.30	1.40	0.60	0.10	0.60	—1.60
2	.80	.70	1.10	2.80	3.10	1.70	4.65	1.20	.60	.20	.60	—1.70
3	1.00	.70	1.10	3.60	2.70	1.50	3.40	1.00	.60	.40	.60	—1.70
4	.60	.60	1.10	2.70	2.30	1.40	3.20	1.00	.60	.40	.60	—1.40
5	.40	.60	1.10	2.40	2.40	1.40	6.80	.80	.60	.25	.60	— .90
6	.50	.60	1.00	2.40	2.30	1.20	5.50	.80	.60	.10	.80	— .50
7	.60	.80	1.15	2.35	2.05	1.00	4.15	.80	.40	.10	.80	— .30
8	.60	.80	1.15	1.95	2.00	1.00	3.50	1.40	.40	.20	.99	+ .10
9	.60	1.00	1.05	2.55	2.00	1.00	2.70	1.80	.40	.10	.90	.10
10	1.00	1.00	1.00	2.60	1.95	1.00	2.00	1.80	.40	.15	.90	.20
11	1.00	1.00	1.00	2.40	1.80	1.00	1.90	1.60	.40	.30	.80	.40
12	1.00	1.00	1.00	2.10	1.75	1.00	2.40	1.20	.40	.20	.80	.40
13	1.00	1.10	1.00	2.00	1.65	1.00	3.70	1.20	.40	.60	.80	.20
14	.80	1.70	1.20	1.95	1.60	1.00	3.90	1.00	.30	.70	1.00	.10
15	.80	1.90	1.20	1.90	1.60	.90	3.40	1.00	.20	.70	.90	— .20
16	.90	1.90	1.35	2.00	1.60	1.10	2.70	1.00	.20	.10	.80	— .70
17	1.00	2.30	1.40	2.05	1.60	1.45	2.00	1.30	.10	.10	.80	—1.00
18	1.00	2.90	1.50	1.65	1.60	1.50	1.70	1.80	.10	.10	.80	—1.00
19	1.00	3.00	1.60	1.60	1.45	2.00	1.60	1.50	.25	.00	.80	+ .10
20	.90	2.65	1.60	1.55	1.40	1.80	1.40	1.75	.10	.20	.80	— .40
21	1.00	2.60	1.40	1.45	1.40	2.00	1.35	1.20	.40	.20	.80	— .50
22	1.00	2.30	1.40	1.40	1.40	3.00	1.30	1.20	.40	.20	.80	— .60
23	1.00	2.15	1.20	1.45	1.35	2.80	1.20	1.00	.40	.30	.80	— .60
24	1.00	1.90	1.30	1.45	1.20	2.60	1.20	.70	.25	.40	.80	— .40
25	.60	1.60	1.25	6.30	1.20	2.05	1.10	.60	.20	.40	.80	— .20
26	.20	1.40	1.20	8.80	1.20	2.80	1.20	.60	.40	.40	.60	+ .40
27	.30	1.20	1.20	7.60	1.20	3.50	1.40	.55	.40	.50	.40	— .10
28	.60	1.30	1.20	7.60	1.20	4.50	1.35	.50	.20	.50	.20	— .10
29	.70	.....	1.30	6.40	2.00	6.00	1.40	.60	.20	.50	.20	.00
30	.80	.....	1.50	4.60	2.00	4.80	1.55	.60	.10	.50	—.70	.00
31	.80	.....	1.85	.....	2.00	.....	1.50	.60	.....	.60	.....	— .10

GRANITE STATION ON ARKANSAS RIVER.

This station is located at the wagon bridge 250 feet from the railroad station at Granite, Colorado. The gage is a vertical 2 by 6 inch plank spiked to the upper end of the center pier of the bridge and graduated to tenths of a foot. The banks are low and liable to overflow; the bed is rocky and the current swift. This station was reestablished April 17, 1897, by Cyrus C. Babb, the records of daily gage heights being kept by the Denver and Rio Grande Railroad Company. The observer is H. D. Marquis. The following is a list of measurements of discharge made in 1897 by F. Cogswell:

April 17, gage height, 3.20 feet; discharge, 120 second-fee
May 8, gage height, 4.20 feet; discharge, 940 second-feet.
May 18, gage height, 4.90 feet; discharge, 1,326 second-feet.
June 29, gage height, 4.60 feet; discharge, 1,151 second-feet.
July 27, gage height, 3.75 feet; discharge, 415 second-feet.
August 31, gage height, 3.20 feet; discharge, 206 second-feet.
September 27, gage height, 3.10 feet; discharge, 203 second-feet.
November 6, gage height, 3.00 feet; discharge, 153 second-feet.

Daily gage height, in feet, of Arkansas River at Granite, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1....	3.35	6.00	4.50	3.65	3.35	3.00	17.....	4.75	5.25	4.00	3.45	3.00	3.00
2....	3.60	6.00	4.35	3.65	3.35	3.00	18.....	4.90	5.00	3.85	3.40	3.15	3.00
3....	3.65	6.00	4.35	3.80	3.35	3.00	19.....	4.90	4.35	3.85	3.35	3.10	3.00
4....	3.55	5.75	4.30	3.70	3.50	3.00	20.....	5.00	4.85	3.85	3.35	3.00	3.00
5....	3.75	5.00	4.25	3.65	3.50	3.00	21.....	5.10	5.00	3.90	3.35	3.00	3.00
6....	3.85	5.00	4.10	3.65	3.40	3.00	22.....	4.90	5.10	3.85	3.35	3.00	3.00
7....	4.05	4.40	4.35	3.75	3.25	3.00	23.....	5.10	5.00	3.90	3.30	3.00	3.00
8....	4.05	4.50	4.35	3.75	3.25	3.00	24.....	5.60	4.90	3.80	3.25	3.00	3.00
9....	4.35	4.50	4.50	3.80	3.25	3.00	25.....	5.60	4.65	3.80	3.25	3.00	3.00
10....	4.25	4.75	4.60	3.65	3.25	3.00	26.....	5.60	4.85	3.75	3.25	3.00	3.00
11....	4.30	5.35	4.40	3.60	3.00	3.00	27.....	5.60	4.90	3.75	3.25	3.00	.....
12....	4.10	5.60	4.35	3.60	3.00	3.00	28.....	5.40	4.75	3.75	3.25	3.00	.....
13....	4.00	5.60	4.15	3.65	3.00	3.00	29.....	5.65	4.60	3.65	3.25	3.00	.....
14....	4.00	6.00	4.00	3.65	3.00	3.00	30.....	5.75	4.45	3.65	3.20	3.00	.....
15....	4.10	5.75	4.05	3.50	3.00	3.00	31.....	6.00	.....	3.65	3.15	.....	.....
16....	4.60	6.15	4.00	3.50	3.00	3.00							

SALIDA STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 224, is located just back of the railroad yards, at a suspension bridge, at Salida, Colorado. The gage consists of a vertical 4 by 6 inch timber, with a 2 by 6 inch scale, bolted to the abutment of the bridge on the left-hand side of the river, and is marked to tenths of a foot. The banks are high and do not overflow; the current is swift; the bed of the stream consists of sand, gravel, and bowlders, but is not subject to any great changes, and is a most desirable station to be maintained. Stream measurements are made from the lower side of the footbridge. River-height observations are maintained by the Denver and Rio Grande Railroad Company. The observer is F. G. Dew. The following discharge measurements were made in 1897 by F. Cogswell:

April 17, gage height, 0.69 foot; discharge, 219 second-feet.
April 27, gage height, 1.55 feet; discharge, 709 second-feet.
May 8, gage height, 2.20 feet; discharge, 1,178 second-feet.
May 30, gage height, 4.05 feet; discharge, 2,821 second-feet.
June 29, gage height, 2.50 feet; discharge, 1,492 second-feet.
July 27, gage height, 1.35 feet; discharge, 606 second-feet.
August 31, gage height, 0.85 foot; discharge, 371 second-feet.
September 27, gage height, 1.00 foot; discharge, 405 second-feet.
November 6, gage height, 0.90 foot; discharge, 378 second-feet.

Daily gage height, in feet, of Arkansas River at Salida, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1....	1.20	4.10	2.30	1.30	1.00	0.65	17.....	2.75	3.00	1.90	1.20	0.90	0.65
2....	1.45	3.60	2.35	1.25	1.00	.65	18.....	3.10	3.00	1.85	1.15	.90	.65
3....	1.75	3.10	2.45	1.25	1.00	.65	19.....	3.00	2.90	2.00	1.10	.90	.65
4....	1.60	2.90	2.35	1.35	1.00	.65	20.....	3.00	2.75	1.90	1.10	1.00	.65
5....	1.60	2.40	2.00	1.45	1.00	.65	21.....	3.00	3.00	1.90	1.00	1.00	.65
6....	1.80	2.45	2.00	1.45	1.05	.65	22.....	2.85	3.00	1.65	1.10	1.00	.65
7....	1.95	2.25	2.00	1.40	1.00	.65	23.....	3.00	3.00	1.50	1.05	1.00	.65
8....	2.25	2.10	2.00	1.45	1.00	.65	24.....	3.50	3.00	1.50	1.00	1.00	.65
9....	2.25	2.35	2.45	1.55	1.00	.65	25.....	3.50	2.80	1.45	1.00	1.00	.65
10....	2.30	2.75	2.45	1.50	1.00	.65	26.....	3.40	2.75	1.40	1.00	1.00	.85
11....	2.30	2.80	2.20	1.40	1.00	.65	27.....	3.60	2.90	1.40	1.00	1.00	.....
12....	2.50	2.90	2.05	1.40	1.00	.65	28.....	3.45	2.55	1.40	1.00	1.00	.....
13....	2.30	3.50	2.00	1.35	1.00	.65	29.....	3.50	2.40	1.25	1.00	1.00	.....
14....	2.35	3.20	1.90	1.35	1.00	.65	30.....	4.00	2.35	1.25	1.00	1.00	.....
15....	2.35	3.35	1.95	1.35	1.00	.65	31.....	4.15	.....	1.25	1.00	.....	.....
16....	2.70	3.65	1.90	1.25	1.00	.65							

CANYON STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 225, is located at the Hot Springs Hotel, 1½ miles west of Canyon, Colorado, about 500 yards below the mouth of Grape Creek. The gage rod is placed on the left bank of the river just below the suspension footbridge, and consists of an inclined 4 by 4 inch by 16-foot timber bolted to a small juniper tree, and to posts set in the ground. A vertical rod is also fastened to the juniper tree for extreme high water. Both banks are high and not liable to overflow. The current is swift, and the cross section is not subject to any notable changes, except at extreme high-and-low-water stages. The observer is Dr. J. L. Prentiss. The following discharge measurements were made in 1897 by F. Cogswell:

April 16, gage height, 2.20 feet; discharge, 260 second-feet.
May 7, gage height, 3.10 feet; discharge, 827 second-feet.
May 26, gage height, 4.95 feet; discharge, 2,712 second-feet.
June 16, gage height, 5.25 feet; discharge, 3,071 second-feet.
July 14, gage height, 3.60 feet; discharge, 1,140 second-feet.
August 11, gage height, 3.05 feet; discharge, 744 second-feet.
November 5, gage height, 2.98 feet; discharge, 540 second-feet.

Daily gage height, in feet, of Arkansas River at Canyon City, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	2.50	2.80	5.40	3.95	2.80	2.40	2.60	3.00	.....
2	2.60	.....	.....	2.50	2.90	5.40	3.85	2.80	2.40	2.50	3.00	.....
3	.....	.....	.....	2.50	3.10	5.40	3.75	2.85	2.40	2.50	3.00	.....
4	.....	.....	.....	2.40	3.05	5.55	3.95	3.60	2.40	2.50	2.90	2.50
5	.....	.....	.....	2.40	3.00	4.85	3.75	3.20	2.40	2.50	2.95	.....
6	.....	2.50	2.50	2.30	3.15	4.25	3.60	3.00	2.40	2.50	2.95	.....
7	.....	.....	.....	2.30	3.10	4.35	3.50	3.10	2.40	2.50	2.95	.....
8	.....	.....	.....	2.20	3.50	4.50	3.50	3.40	2.40	2.60	2.90	.....
9	2.50	.....	.....	2.20	3.60	4.60	4.17	3.30	2.45	2.70	2.90	.....
10	.....	.....	.....	2.10	3.70	4.70	3.90	3.20	2.45	2.70	2.90	.....
11	.....	.....	.....	2.15	3.65	4.65	4.00	3.10	2.45	2.70	2.90	2.60
12	.....	.....	.....	2.20	3.60	4.95	3.85	3.10	2.50	2.70	2.95	.....
13	.....	2.40	2.60	2.20	3.70	5.35	3.70	3.00	2.50	2.60	2.95	.....
14	.....	.....	.....	2.20	3.80	5.25	3.60	2.90	2.60	2.65	3.00	.....
15	.....	.....	.....	2.10	4.10	5.15	3.75	2.90	2.60	2.70	2.95	.....
16	2.30	.....	.....	2.20	4.30	5.30	3.55	2.80	2.60	2.80	2.85	.....
17	.....	.....	.....	2.20	4.50	5.15	3.50	2.80	2.60	2.80	2.85	.....
18	.....	.....	.....	2.35	4.30	4.65	3.50	2.70	*2.55	2.80	2.85	2.60
19	.....	.....	.....	2.40	4.30	4.50	3.70	2.70	2.55	2.85	2.85	.....
20	.....	2.50	2.50	2.50	4.25	4.50	3.60	2.60	2.50	2.85	2.85	.....
21	.....	.....	.....	2.55	4.30	4.50	3.50	2.60	2.50	2.80	.....	.....
22	.....	.....	.....	2.45	4.35	4.50	3.40	2.60	2.50	2.80	2.85	.....
23	2.40	.....	.....	2.25	4.40	4.50	3.30	2.70	2.50	2.80	2.85	.....
24	.....	2.70	.....	2.20	4.75	4.45	3.20	2.55	2.50	2.80	2.75	.....
25	.....	2.70	.....	2.20	5.00	4.45	3.20	2.50	2.50	2.80	2.70	2.50
26	.....	.....	.....	2.30	5.05	4.50	3.10	2.50	2.50	2.80	2.70	.....
27	.....	2.50	2.60	2.55	5.00	4.35	3.00	2.50	2.50	2.80	2.70	.....
28	.....	.....	2.60	2.55	5.05	4.25	2.90	2.50	2.50	2.90	2.65	.....
29	.....	.....	2.70	2.85	5.10	4.05	2.90	2.50	2.50	3.00	2.60	.....
30	2.50	.....	2.60	2.75	5.35	4.00	2.85	2.50	2.50	3.00	2.50	.....
31	.....	.....	2.50	.....	5.45	.....	2.80	2.40	.....	.....	.....	.....

PUEBLO STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 227, is located at the city of Pueblo, Colorado, 2 miles above the mouth of Fountain Creek. There are two gage rods. The main one, at Santa Fe avenue bridge, consists of a vertical 6 by 6 inch timber, bolted to the abutment of the Denver and Rio Grande Railroad bridge on the left-hand side of the river, marked to tenths of a foot. There is also a short vertical rod for extreme low water spiked to a pile about 20 feet out in the stream, reading same as the main gage. The 12-foot mark of this gage is opposite the top of the large capstone. The rod at Victoria avenue bridge consists of inclined 4 by 4 inch timbers fastened to posts set in right bank of stream, and was placed for the purpose of noting the change in the slope of the water surface. Stream measurements are made from lower side of the Main street bridge. The river is confined by the city levees, and the bed is sandy and constantly changing. The observer is R. L. Holden. The following is a list of discharge measurements made in 1897 by F. Cogswell and others:

April 16, gage height, 0.20 foot; discharge, 216 second-feet.
May 6, gage height, 1.00 foot; discharge, 799 second-feet.
May 21, gage height, 2.00 feet; discharge, 1,856 second-feet.
June 18, gage height, 2.55 feet; discharge, 2,219 second-feet.
July 16, gage height, 1.15 feet; discharge, 981 second-feet.
August 10, gage height, 0.95 foot; discharge, 805 second-feet.
September 8, gage height, 0.10 foot; discharge, 184 second-feet.
September 28, gage height, 0.45 foot; discharge, 394 second-feet.
November 4, gage height, 0.75 foot; discharge, 601 second-feet.

Daily gage height, in feet, of Arkansas River at Pueblo, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	0.65	0.30	0.20	0.70	3.30	1.45	0.55	0.20	0.20	0.70	0.45
2	.30	.40	.30	.00	.75	3.50	1.55	.60	.20	.20	.70	.50
3	.30	.40	.30	.15	1.00	3.05	1.65	.80	.10	.20	.70	.40
4	.35	.45	.25	.20	1.05	2.50	1.45	.65	.10	.25	.70	.45
5	.35	.35	.15	.15	.95	2.15	1.45	.95	.10	.30	.70	.40
6	.25	.35	.10	.05	.95	2.05	1.45	.60	.10	.30	.70	.40
7	.35	.45	.10	.00	1.05	1.90	1.65	1.20	.10	.35	.60	.45
8	.45	.40	.05	.10	1.30	1.75	1.10	1.05	.10	.40	.60	.50
9	.25	.35	.00	.00	1.40	1.70	2.10	1.45	.05	.35	.60	.50
10	.45	.40	.05	.05	1.45	2.00	2.00	1.00	.00	.55	.50	.50
11	.45	.45	.00	.00	1.45	2.45	1.85	.95	.10	.35	.55	.45
12	.50	.40	.00	.05	1.45	2.85	1.60	.90	.10	.45	.70	.40
13	.45	.45	.05	.10	1.35	2.90	1.35	.75	.25	.35	.70	.40
14	.35	.30	.05	.00	1.40	3.20	1.20	.55	.30	.35	.70	.50
15	.35	.20	.05	.00	1.45	3.00	2.10	.40	.50	.35	.70	.45
16	.30	.15	.15	.00	1.60	2.95	1.25	.40	.40	.45	.60	.40
17	.35	.40	.00	.15	1.90	3.05	1.15	.30	.35	.60	.50	.50
18	.25	.40	.25	.20	1.90	2.55	1.25	.30	.35	.60	.40	.45
19	.30	.30	.20	.30	2.20	2.30	1.45	.30	.40	.65	.50	.30
20	.30	.40	.20	.30	2.15	2.15	1.35	.30	.30	.70	.45	.30
21	.35	.35	.15	.35	2.00	2.30	1.15	.20	.30	.65	.40	.30
22	.30	.35	.15	.35	1.90	2.20	1.00	.20	.35	.60	.55	.30
23	.35	.40	.10	.30	1.85	2.15	.85	.20	.30	.55	.50	.20
24	.30	.25	.05	.10	2.15	2.00	.85	.40	.30	.55	.50	.20
25	.25	.25	.00	.25	2.85	1.95	.75	.35	.30	.50	.50	.20
26	.20	.25	.10	.30	2.85	1.85	.75	.25	.35	.65	.50	.20
27	.30	.25	.20	.30	2.75	2.00	.85	.20	.40	.60	.50	.30
28	.25	.20	.25	.35	3.05	1.90	.85	.10	.40	.50	.40	.40
29	.35	.....	.40	.65	2.80	1.65	.70	.20	.40	.60	.40	.45
30	.65	.....	.40	.75	3.15	1.50	.55	.20	.35	.65	.45	.40
31	.50	.....	.30	.....	3.30	.....	.55	.20	.....	.65	.....	.30

NEPESTA STATION ON ARKANSAS RIVER.

This station is located 1,000 feet north of Nepesta, Colorado, at a wagon bridge, 200 feet below Atchison, Topeka and Santa Fe Railroad bridge, and was established September 8, 1897. The gage consists of a vertical 2 by 6 inch by 12 foot timber marked in tenths, securely wired to upstream side of upstream cylinder of bridge on left side of river and marked with 1 by 6 inch scale on face and 1 by 3 inch scale on side. The initial point for soundings is on the left bank, which is low and liable to overflow. The right bank is high and riprapped above railroad bridge. The channel above and below the station is straight for 300 or 400 feet; the bed is sandy and shifting. The observer is G. J. Boyd, a storekeeper, who lives 1,000 feet from the gage. The following discharge measurements were made by Porter J. Preston in 1897:

September 8, gage height, 2.00 feet; discharge, 168 second-feet.
September 30, gage height, 2.34 feet; discharge, 281 second-feet.

Daily gage height, in feet, of Arkansas River at Nepesta, Colorado, for 1897.

Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.
1	.....	2.20	9	.....	2.15	17	.....	.....	25	2.00	.....
2	.....	2.10	10	.....	2.15	18	.....	.....	26	2.00	.....
3	.....	2.00	11	.....	2.20	19	1.90	.....	27	2.00	.....
4	.....	2.10	12	.....	2.35	20	1.50	.....	28	2.10	.....
5	.....	2.00	13	.....	1.75	21	1.80	.....	29	2.00	.....
6	.....	2.20	14	.....	2.00	22	2.10	.....	30	2.00	.....
7	.....	2.10	15	.....	2.10	23	2.00	.....	31	.....	.....
8	.....	2.05	16	.....	2.00	24	2.10	.....			

ROCKY FORD STATION ON ARKANSAS RIVER.

This station is located 2 miles northeast of Rocky Ford, Colorado, and was established May 3, 1897. The gage consists of a vertical 1 by 3 inch timber notched in tenths and securely nailed to pile protection to abutment of wagon bridge, left side of stream, upper side of bridge. The initial point of soundings is on the left bank at water's edge. Both banks are high and liable to overflow only at very high water. The channel is straight for about 300 feet above and below the station. The bed is sandy and shifting. The observer, S. W. Cressy, whose occupation is water commissioner, lives 2 miles distant from the gage. The following discharge measurement was made by Porter J. Preston in 1897:

September 29, gage height, 0.37 foot; discharge, 140 second-feet.

Daily gage height, in feet, of Arkansas River at Rocky Ford, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.70	0.72	0.65	0.45	0.40	0.92	0.38
2	.....	2.50	.55	.65	.50	.38	1.02	.40
3	1.00	2.82	.80	.68	.42	.30	1.10	(a)
4	1.10	2.52	1.42	.69	.32	.32	1.10	.....
5	1.28	2.08	1.50	1.94	.25	.25	1.08	.....
6	1.25	2.40	1.50	1.60	.35	.32	1.10	.....
7	.90	1.98	1.25	1.28	.35	.35	.88	.....
8	.50	1.80	1.10	2.05	.30	.38	.68	.....
9	1.02	1.65	1.00	1.60	.30	.40	.00	.....
10	1.18	1.65	1.52	1.90	.18	.50	.60	.....
11	1.23	1.72	1.60	1.02	.30	.78	.58	.....
12	1.15	2.10	1.26	.60	.30	.65	.50	.....
13	1.37	2.40	1.26	1.28	.35	.45	.65	.....
14	1.42	2.40	1.17	.75	.35	.40	.48	.....
15	1.42	2.48	1.33	.82	.20	.60	.60	.....
16	1.32	2.22	1.41	3.10	.45	.72	.60	.....
17	1.40	2.20	.82	2.10	.66	.80	.48	.....
18	1.50	2.15	1.38	.95	.70	.80	.45	.....
19	1.60	2.00	2.05	1.15	.45	.82	.42	.....
20	1.55	1.75	1.80	.95	.38	.88	.....	.....
21	1.60	1.62	1.02	.80	.25	.90	.50	.....
22	1.45	1.50	.62	.60	.15	.88	.50	.....
23	1.48	1.50	.50	.55	.20	.85	.45	.....
24	1.50	1.25	.40	.70	.20	.84	.50	.....
25	1.49	1.17	.35	.58	.22	.85	.50	.....
26	1.80	1.24	.35	.48	.30	.98	.50	.....
27	1.85	1.17	.61	.38	.35	1.00	.53	.....
28	2.90	1.82	.65	.30	.35	.98	.50	.....
29	2.00	1.75	.85	.22	.38	.92	.51	.....
30	2.05	1.22	.85	.20	.40	.80	.35	.....
31	2.38	.....	.68	.32	.....	.80	.....	.....

a River frozen.

TRINIDAD STATION ON PURGATOIRE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 231, is located at the Las Animas street bridge in the city of Trinidad, Colorado. The gage consists of a vertical 2 by 6 inch plank, and is fastened with iron bands to the downstream side of a cylindrical bridge pier, on the right side of the river. The banks are high and not liable to overflow, the bed is of gravel and small stones, and the water moves with fair velocity. Stream measurements are made from the lower side of the bridge during high water, and at low stages by wading some 400 feet below the gage. The observer is J. N. Turner, water commissioner. The following measurements of discharge were made in 1897 by F. Cogswell:

May 22, gage height, 4.25 feet; discharge, 677 second-feet.
June 17, gage height, 4.10 feet; discharge, 386 second-feet.
July 15, gage height, 3.90 feet; discharge, 189 second-feet.
September 23, gage height, 3.60 feet; discharge, 49 second-feet.
November 13, gage height, 3.55 feet; discharge, 46 second-feet.

Daily gage height, in feet, of Purgatoire River at Trinidad, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.75	4.05	4.20	4.15	3.50	3.50	3.60	3.60
2	3.70	4.15	4.25	4.05	3.45	3.50	3.60	3.60
3	3.75	4.05	4.30	4.00	3.65	3.50	3.60	3.55
4	3.75	4.30	4.20	3.90	3.60	3.50	3.60	3.55
5	3.75	4.30	4.05	3.90	3.55	3.55	3.60	3.50
6	3.65	4.35	4.00	3.85	4.00	3.60	3.60	3.50
7	3.75	4.30	4.00	3.80	3.85	3.55	3.60	3.60
8	3.75	4.30	4.00	3.80	4.80	3.50	3.60	3.60
9	3.80	4.40	4.00	4.65	4.25	3.60	3.65	3.60
10	3.85	4.30	4.00	4.20	4.10	3.95	3.60	3.60
11	3.75	4.25	4.00	4.10	3.95	3.95	3.60	3.60
12	3.80	4.20	4.05	4.00	4.00	3.90	3.60	3.60
13	3.90	4.30	4.10	3.95	3.90	4.10	3.60	3.60
14	3.90	4.30	4.15	3.90	3.90	3.90	3.60	3.60
15	3.85	4.30	4.10	3.90	4.70	3.90	3.60	3.50
16	3.75	4.15	4.10	3.95	4.00	4.05	3.60	3.55
17	3.80	4.20	4.10	4.00	4.00	3.85	3.75	3.55
18	3.75	4.20	4.05	4.00	4.00	3.75	3.65	3.50
19	3.90	4.35	4.00	3.95	3.90	3.60	3.60	3.50
20	3.90	4.55	4.00	3.90	4.00	3.55	3.60	3.50
21	4.00	4.40	3.90	3.90	3.90	3.60	3.60	3.50
22	3.90	4.22	3.90	3.80	4.00	3.50	3.60	3.50
23	3.85	4.20	3.90	3.80	4.00	3.60	3.60	3.50
24	3.95	4.20	3.90	3.80	3.90	3.60	3.60	3.60
25	4.00	4.20	3.90	3.80	3.60	3.50	3.70	3.60
26	3.95	4.30	4.60	3.80	3.45	3.60	3.70	3.60
27	3.90	4.35	4.25	3.80	3.40	3.60	3.65	3.50
28	4.00	4.30	4.05	3.80	3.30	3.60	3.65	3.50
29	4.00	4.25	4.00	3.75	3.35	3.60	3.65	3.50
30	4.05	4.30	4.20	3.55	3.40	3.60	3.60	3.50
31	.....	4.30	.....	3.50	3.40	.....	3.60	.....

HUTCHINSON STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 232, is located at the wagon bridge at the south end of Main street, Hutchinson, Kansas. The observer is Daniel Lauer, who lives about 100 yards from the station. The gage consists of an oak timber painted white, graduated in feet and tenths and spiked to an oak pile a few feet above the bridge, driven as a protection to the bridge pier from ice and drift. There are two bench marks: One is the upper cross piece of the pier guard, having an elevation of 8.35 feet above zero; the second is the top of the iron doorsill, next to the river, of the first brick building. Its elevation is 8.12 feet above zero of the gage. Measurements are made from the bridge, and at low water may be made by wading. The channel is generally straight for some distance, both above and below, and is sandy and very shifting. At very low stages the water is in several channels and crooked. The following discharge measurements were made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 25...	2.30	471	May 18....	2.00	202	Aug. 3 ...	1.15	6
Mar. 25...	1.75	158	June 3....	1.60	60	Aug. 20 ..	2.20	275
Apr. 14...	2.00	221	June 29...	2.10	284	Sept. 29 ..	1.10	4
Apr. 22...	1.70	122	July 14....	1.30	15			
May 7....	1.95	170	July 27....	1.10	4			

Daily gage height, in feet, of Arkansas River at Hutchinson, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.80	2.20	1.70	2.15	1.60	1.85	1.35	2.00	1.10	1.30	(a)
2	1.60	1.80	2.15	1.70	2.10	1.60	1.75	1.15	1.95	1.10	1.30	(a)
3	1.80	1.80	2.30	1.80	2.05	1.55	1.70	1.05	1.90	1.10	1.30	(a)
4	1.80	2.20	2.30	1.80	2.00	1.55	1.95	1.00	1.80	1.10	1.30	(a)
5	1.80	2.20	2.25	1.90	2.00	1.60	1.75	1.00	1.75	1.10	1.30	1.65
6	1.80	2.20	2.20	2.05	2.00	1.60	1.55	1.10	1.65	1.10	1.30	1.70
7	1.80	1.70	2.20	2.10	2.00	1.60	1.55	1.10	1.55	1.10	1.30	1.60
8	1.80	1.80	2.10	2.20	1.95	1.60	1.45	1.10	1.50	1.10	1.30	1.50
9	1.80	1.80	2.10	2.20	1.90	1.60	1.40	1.10	1.50	1.10	1.30	1.50
10	1.80	1.90	2.10	2.20	2.10	1.55	1.65	1.05	1.45	1.10	1.30	1.50
11	1.80	2.45	2.00	2.15	2.30	1.90	1.50	1.00	1.40	1.10	1.30	1.50
12	1.80	2.35	1.90	2.10	2.40	2.10	1.50	1.00	1.35	1.05	1.30	1.50
13	1.70	2.25	1.90	2.05	2.35	2.20	1.40	1.00	1.30	1.00	1.30	1.45
14	1.70	2.80	2.10	1.95	2.30	2.20	1.35	1.45	1.30	1.00	1.20	1.40
15	1.70	2.70	1.85	1.90	2.15	2.20	1.30	1.30	1.30	1.00	1.20	1.40
16	1.70	1.65	1.80	1.85	2.10	2.20	1.30	1.15	1.75	1.05	1.20	1.40
17	1.70	1.60	1.80	1.80	2.05	2.20	1.30	2.05	1.65	1.20	1.20	1.40
18	1.70	1.60	1.80	1.80	2.00	2.20	1.30	2.25	1.55	1.45	1.20	1.40
19	1.80	1.60	1.80	1.80	1.90	2.15	1.30	2.30	1.50	1.40	1.20	1.40
20	1.90	2.05	1.80	1.80	1.90	2.20	1.25	2.20	1.45	1.40	1.20	1.40
21	1.90	2.50	1.80	1.70	1.90	2.20	1.20	2.15	1.40	1.40	1.20	1.40
22	1.90	2.50	1.80	1.70	1.90	2.20	1.10	2.00	1.35	1.40	1.20	1.40
23	1.90	2.45	1.80	1.70	1.85	2.30	1.10	2.20	1.30	1.30	1.20	1.40
24	1.90	2.35	1.80	1.85	1.80	2.30	1.10	2.65	1.30	1.30	1.30	1.40
25	1.90	2.30	1.75	2.10	1.75	2.30	1.20	2.95	1.25	1.35	1.35	1.40
26	1.80	2.30	1.70	2.15	1.70	2.30	1.20	2.75	1.20	1.40	1.40	1.40
27	1.60	2.20	1.70	2.20	1.70	2.25	1.30	2.55	1.20	1.30	1.40	1.40
28	1.60	3.85	1.70	2.20	1.70	2.15	1.35	2.30	1.20	1.30	1.30	1.40
29	1.60	.....	1.70	2.20	1.65	2.10	1.70	2.20	1.10	1.30	1.30	1.40
30	1.60	.....	1.70	2.20	1.60	2.05	1.60	2.20	1.10	1.30	1.30	1.40
31	1.80	.....	1.70	.....	1.60	.....	1.45	2.10	.....	1.30	.....	1.40

a Frozen.

LIBERTY STATION ON VERDIGRIS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 235, is located at a wagon bridge, about 250 feet below McTaggart's milldam, about 3 miles southwest of the town of Liberty, Kansas. The gage is in two parts—a vertical board marked to feet and tenths fastened to the flume, which serves to give ordinary heights, and horizontal marks one-half foot apart on the corner of wheelhouse. The zero of gage is 12.46 feet below the heads of three large nails in flume. Bench mark 2 is the head of a spike in root of cottonwood tree 4.75 feet in circumference and 40 feet south of gage. The spike has a circle cut around it, with letters U. S. above. Its elevation is 10.98 feet above datum. The bed is rock and gravel, and subject to very little change. September 11, 1897, a secondary gage was placed about 7 miles above gage No. 1. It is located at the Independence waterworks, and is to be read hourly when the river is in flood. The zeros of the two gages are referred to the same datum. The observer is A. C. McTaggart. The following discharge measurements were made in 1897 by E. C. Murphy:

April 2, gage height, 6.55 feet; discharge, 2,558 second-feet.
April 3, gage height, 5.87 feet; discharge, 2,003 second-feet.
April 30, gage height, 17.00 feet; discharge, 10,367 second-feet.
May 1, gage height, 7.38 feet; discharge, 3,384 second-feet.
June 29, gage height, 2.35 feet; discharge, 70 second-feet.
July 20, gage height, 3.00 feet; discharge, 312 second-feet.
September 8, gage height, 1.95 feet; discharge, 14 second-feet.

Daily gage height, in feet, of Verdigris River at Liberty, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.60	3.60	10.15	7.20	2.90	2.40	2.20	2.00	2.00	1.70	1.60
2	3.80	.....	3.60	7.05	5.80	2.90	2.40	2.20	2.00	.....	.....	.....
3	.....	3.40	3.80	5.70	5.25	3.10	2.40	2.20	2.00	.....	1.60	1.60
4	4.00	.....	5.00	5.05	4.95	2.90	2.40	2.20	2.00	1.90	.....	.....
5	.....	9.80	20.00	4.75	4.65	2.90	2.45	2.20	2.00	.....	1.60	.....
6	3.80	.....	13.75	4.55	4.45	2.90	9.45	2.20	2.00	1.80	.....	1.70
7	.....	.....	7.50	4.35	4.35	3.00	6.90	2.20	2.00	.....	.....	.....
8	.....	6.00	6.00	4.30	4.15	3.00	5.00	2.10	2.00	1.80	1.60	1.70
9	3.30	.....	7.15	4.30	4.10	8.25	3.70	2.10	2.00	.....	.....	.....
10	.....	5.60	6.90	4.55	4.10	6.65	2.95	2.10	2.00	.....	1.60	1.70
11	3.20	.....	5.80	5.00	6.05	4.75	2.75	2.10	2.00	1.80	.....	.....
12	.....	7.20	4.95	4.70	13.25	4.10	2.60	2.10	.....	.....	1.60	.....
13	4.20	.....	4.80	4.30	6.85	3.60	2.50	2.10	2.00	1.80	.....	1.70
14	.....	.....	4.35	4.15	5.10	3.40	2.50	2.10	.....	.....	.....	.....
15	.....	5.00	4.25	4.00	4.80	3.30	2.45	2.10	2.00	1.80	1.60	1.90
16	4.30	.....	4.10	3.85	4.50	3.30	2.40	2.10	.....	.....	.....	.....
17	.....	5.30	5.05	3.70	4.30	3.20	2.40	2.10	.....	.....	1.60	1.90
18	5.10	.....	5.80	3.60	4.15	3.10	2.40	2.10	2.00	1.70	.....	.....
19	.....	4.60	5.40	3.60	3.95	3.00	2.60	2.10	.....	.....	1.60	.....
20	5.30	.....	5.55	3.60	3.75	3.10	2.95	2.10	2.00	1.70	.....	1.90
21	.....	.....	5.70	3.60	3.55	3.35	3.05	2.10	.....	.....	.....	.....
22	5.30	4.40	5.10	3.40	3.35	3.10	2.80	2.00	2.00	1.70	1.60	2.20
23	.....	.....	4.60	3.40	4.05	2.80	2.80	2.00	.....	.....	.....	.....
24	.....	4.00	4.20	3.40	3.95	2.70	2.70	2.00	.....	.....	1.60	2.20
25	4.70	.....	4.00	6.85	3.70	2.60	2.55	2.00	2.00	1.70	.....	.....
26	.....	4.00	3.95	6.70	3.55	2.50	2.35	2.00	.....	.....	1.60	.....
27	4.10	.....	3.80	4.85	3.20	2.50	2.20	2.00	2.00	1.70	.....	1.75
28	.....	.....	3.80	18.75	3.10	2.40	2.20	2.00	.....	.....	.....	.....
29	3.80	.....	3.80	28.20	3.00	2.40	2.20	2.00	2.00	1.70	1.60	1.90
20	.....	.....	6.50	21.50	3.00	2.30	2.20	2.00	.....	.....	.....	.....
31	.....	.....	9.30	.....	3.00	.....	2.20	2.00	.....	.....	.....	1.90

IOLA STATION ON NEOSHO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 238, is located at a highway bridge 1 mile west of the city of Iola, Kansas. The gage is in two parts—one part, a vertical board marked to feet and tenths and fastened to flume, serves to give ordinary heights; the other is a smooth stone wall near by, having horizontal lines on it one-half foot apart, for use when the water is high. The zero is 13.30 feet below the heads of three large nails driven into crosspiece of flume. The observer is Elias Bruner. The following is a list of discharge measurements made by E. C. Murphy in 1897:

March 19, gage height, 3.15 feet; discharge, 566 second-feet.
April 1, gage height, 4.60 feet; discharge, 2,049 second-feet.
April 2, gage height, 4.35 feet; discharge, 1,752 second-feet.
May 1, gage height, 3.28 feet; discharge, 544 second-feet.
June 28, gage height, 4.75 feet; discharge, 2,226 second-feet.
December 1, gage height, 1.80 feet; discharge, 1 second-foot.

Daily gage height, in feet, of Neosho River at Iola, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	3.20	2.95	4.75	3.30	2.40	2.25	2.00	2.05	1.80	1.80	1.80
2	2.30	3.50	3.05	4.20	3.30	2.40	2.20	2.10	2.00	1.80	1.80	1.80
3	2.40	3.90	3.00	4.10	3.30	2.40	2.20	2.10	2.00	1.80	1.80	1.80
4	2.50	5.90	3.10	3.85	3.20	2.45	2.25	2.10	2.00	1.80	1.80	1.80
5	2.60	4.70	6.35	3.65	3.20	2.50	2.35	2.10	1.90	1.80	1.80	1.80
6	2.60	3.20	5.05	3.45	3.15	2.50	2.30	2.10	1.90	1.80	1.80	1.80
7	2.60	3.30	4.00	3.40	3.10	2.50	2.20	2.10	1.80	1.80	1.80	1.80
8	2.70	3.15	3.55	3.60	3.10	2.45	2.65	2.00	1.80	1.80	1.80	1.80
9	2.90	3.45	3.45	3.90	3.10	2.40	2.70	2.10	1.80	1.80	1.80	1.80
10	2.90	3.75	3.25	4.00	3.00	2.40	2.90	2.10	1.80	1.80	1.80	1.80
11	2.95	4.25	3.05	4.00	3.00	3.60	2.95	2.10	1.80	1.80	1.80	1.80
12	3.10	5.15	2.95	4.00	3.00	3.55	2.85	2.10	1.80	1.80	1.80	1.80
13	3.15	4.85	2.90	3.90	3.00	3.25	2.75	2.10	1.80	1.80	1.80	1.80
14	3.20	4.80	2.90	3.80	2.90	3.15	2.65	2.10	1.80	1.80	1.80	1.80
15	3.20	5.85	2.80	3.65	2.90	2.85	2.50	2.00	1.80	1.80	1.80	1.80
16	3.15	5.30	2.85	3.40	2.90	2.75	2.40	2.10	1.80	1.80	1.80	1.80
17	3.00	4.80	2.90	3.20	2.80	2.55	2.30	2.10	1.80	1.80	1.80	1.80
18	3.20	5.40	2.90	3.10	2.80	2.35	2.30	2.10	1.80	1.80	1.80	1.80
19	3.20	5.85	3.05	3.10	2.70	2.25	2.25	2.15	1.80	1.80	1.80	1.80
20	3.30	5.20	4.85	3.10	2.70	2.30	2.25	2.15	1.80	1.80	1.80	1.80
21	3.40	4.65	3.85	3.00	2.60	2.25	2.20	2.15	1.80	1.80	1.80	1.80
22	3.50	4.30	3.50	3.00	2.60	2.20	2.20	2.10	1.80	1.80	1.80	1.80
23	3.60	3.85	3.05	3.00	2.50	2.20	2.20	2.10	1.80	1.80	1.80	1.80
24	3.60	3.25	3.25	2.90	2.50	2.10	2.20	2.10	1.80	1.80	1.80	1.80
25	3.50	2.70	3.20	2.90	2.50	2.10	2.15	2.10	1.80	1.70	1.80	1.80
26	3.50	3.30	3.10	3.10	2.50	2.50	2.15	2.10	1.80	1.70	1.80	1.80
27	3.40	3.00	3.00	3.10	2.40	3.85	2.15	2.10	1.80	1.70	1.80	1.80
28	3.35	2.90	3.00	3.45	2.40	3.85	2.15	2.10	1.80	1.70	1.80	1.80
29	3.30	.....	3.00	3.55	2.40	4.10	2.15	2.00	1.80	1.70	1.80	1.80
30	3.30	.....	4.80	3.45	2.40	2.75	2.15	2.05	1.80	1.70	1.80	1.80
31	3.30	.....	5.35	.....	2.40	.....	2.15	2.05	.....	1.80	.....	1.80

DEL NORTE STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 246, is located about two miles above the town of Del Norte, Colorado. The gage consists of an inclined 2 by 6 inch plank, fastened to posts driven into the right bank of the river. Bench mark No. 1 is a large nail in the root of a tree 15 feet northwest of the end of the cable on left bank of river. Bench mark No. 2 is a large nail in the root of a tree 25 feet southwest of the end of the inclined gage. Both bench marks are 7.54 feet above gage datum. While the banks are not high, the river has never been known to overflow. The current is swift; the bed is composed of small stones and the cross section does not change materially. Discharge measurements are made from a box suspended from a five-eighth inch wire cable fastened to trees on each side of the river. The observer is J. S. Regan. The following discharge measurements were made in 1897 by F. Cogswell:

April 26, gage height, 3.00 feet; discharge, 1,507 second-feet.
May 17, gage height, 4.05 feet; discharge, 3,014 second-feet.
May 29, gage height, 5.45 feet; discharge, 4,898 second-feet.
June 28, gage height, 3.30 feet; discharge, 1,769 second-feet.
July 26, gage height, 2.00 feet; discharge, 640 second-feet.
August 30, gage height, 1.55 feet; discharge, 373 second-feet.
October 25, gage height, 2.66 feet; discharge, 1,113 second-feet.

Daily gage height, in feet, of Rio Grande at Del Norte, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	2.18	3.40	5.42	3.40	1.88	1.48	2.22	2.36	.....
2	1.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	2.24	3.52	5.30	3.56	1.90	1.54	2.50	2.28	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.30
5	.....	.....	.....	2.24	3.14	5.20	3.18	1.86	1.70	3.36	2.26	.....
6	.....	2.78	2.98	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	2.16	3.86	4.42	2.76	1.92	2.00	3.08	2.18	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	2.64	.....	.....	2.00	4.14	4.60	3.00	1.96	1.78	3.54	2.14	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	1.96	4.08	4.78	2.84	1.84	1.76	3.26	2.22	2.18
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	2.82	2.64	2.04	4.26	4.76	2.62	1.76	2.48	3.38	2.12	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	2.24	4.48	4.82	2.50	1.72	2.12	3.50	2.00	.....
16	2.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	.....	.....	2.90	4.22	4.16	2.48	1.76	1.98	3.24	1.98	.....
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.86
19	.....	.....	.....	3.46	4.50	3.84	2.32	1.70	2.02	3.12	1.96	.....
20	.....	2.84	2.38	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	.....	3.20	4.36	3.92	2.18	1.64	2.00	2.96	1.94	.....
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	2.72	.....	.....	2.60	5.12	4.00	2.14	1.60	2.06	2.82	1.90	.....
24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	2.70	5.56	3.56	2.10	1.56	2.20	2.66	1.86	2.72
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	2.76	2.04	2.94	5.70	3.16	1.98	1.54	2.46	2.54	1.84	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	3.04	5.40	3.38	1.94	1.52	2.24	2.46	1.88	.....
30	2.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.92	.....
31	.....	.....	2.12	.....	5.58	.....	1.92	1.50	.....	2.44	.....	2.66

EMBUDO STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 248, is located about 300 feet east of the railroad depot of Embudo, New Mexico. The observer is A. H. Wasson. Equipment consists of a five-eighths inch cable and car with tagged wire. The gage is inclined, and consists of 4 by 4 timber, notched and marked every tenth of a foot vertically and spiked to small hand-driven piles. The bench marks are as follows: No. 1 is a rock near the end of cable, left bank, marked "B. M." with white paint, and is 20.66 feet above datum. No. 2, rock 100 feet above cable, left bank, marked similarly and is 18.79 feet above datum; No. 3, notch cut in southeast corner of station house 2 feet above platform and is 30.48 feet above datum. The initial point of sounding is on the right bank. The left bank is steep and the right bank of more gentle slope. The following discharge measurements were made in 1897 by P. E. Harroun:

February 27, gage height, 7.90 feet; discharge, 414 second-feet.
March 19, gage height, 8.80 feet; discharge, 672 second-feet.
June 10, gage height, 12.20 feet; discharge, 5,122 second-feet.
June 23, gage height, 10.55 feet; discharge, 2,735 second-feet.
July 11, gage height, 9.50 feet; discharge, 1,527 second-feet.
July 24, gage height, 8.30 feet; discharge, 640 second-feet.
August 12, gage height, 7.40 feet; discharge, 312 second-feet.
August 29, gage height, 7.60 feet; discharge 273 second-feet.
September 13, gage height, 7.60 feet; discharge, 296 second-feet.
October 8, gage height, 9.60 feet; discharge, 1,501 second-feet.
October 25, gage height, 9.70 feet; discharge, 1,511 second-feet.

Daily gage height, in feet, of Rio Grande at Embudo, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.70	7.70	8.10	8.80	10.85	13.85	9.90	7.60	7.60	8.20	9.50	8.70
2	7.70	7.70	8.25	8.75	11.15	13.90	9.80	7.60	7.60	8.30	9.50	8.50
3	7.70	7.80	8.20	8.70	11.25	13.75	9.75	7.60	7.70	8.30	9.50	8.50
4	7.70	7.85	8.20	8.70	11.60	13.35	9.65	7.50	7.60	9.05	9.50	8.40
5	7.70	7.90	8.05	8.75	11.55	12.95	9.60	7.45	7.55	8.45	9.60	8.20
6	7.70	7.90	7.95	8.70	11.35	12.45	9.50	7.40	7.50	8.30	9.60	8.30
7	7.70	7.90	7.90	8.90	11.35	12.10	9.35	7.50	7.50	8.60	9.50	8.20
8	7.70	7.90	7.90	8.90	11.30	12.10	9.55	7.55	7.50	9.60	9.50	8.25
9	7.70	7.90	8.10	9.05	11.40	12.10	9.70	7.60	7.50	9.80	9.50	8.40
10	7.70	7.90	8.20	9.10	11.65	12.10	9.50	7.50	7.50	9.80	9.50	8.40
11	7.70	7.95	8.05	9.15	12.00	12.30	9.50	7.50	7.60	10.10	9.50	8.30
12	7.70	7.95	8.25	9.30	12.00	12.35	9.55	7.40	7.60	10.20	9.50	8.40
13	7.70	7.90	8.25	9.30	11.85	12.45	9.65	7.40	7.65	10.15	9.50	8.30
14	7.80	7.90	8.30	9.30	11.90	12.40	9.65	7.35	7.60	10.10	9.50	8.10
15	7.90	7.85	8.25	9.45	11.95	12.40	10.36	7.30	7.60	10.15	9.50	8.20
16	7.90	7.80	8.30	9.50	12.15	12.35	10.00	7.40	7.70	10.20	9.50	8.30
17	7.90	7.95	8.40	9.55	12.20	12.25	9.50	7.50	7.70	10.20	9.40	8.30
18	7.90	7.90	8.40	9.95	12.25	12.00	9.50	7.45	7.75	10.25	9.35	8.40
19	7.95	7.90	8.40	10.30	12.55	11.70	9.35	7.40	7.80	10.30	9.20	8.30
20	8.00	7.90	8.50	10.35	13.05	11.20	9.05	7.40	7.80	10.25	9.00	8.30
21	8.00	7.85	8.60	10.70	13.40	11.00	8.80	8.90	7.80	10.15	9.00	8.40
22	8.00	7.85	8.60	10.70	13.40	10.75	8.70	7.60	7.85	9.55	8.90	8.30
23	8.00	7.90	8.45	10.75	13.20	10.50	8.55	7.60	7.90	10.15	8.85	8.20
24	8.00	7.80	8.20	10.60	13.10	10.45	8.30	7.60	7.85	9.95	8.80	8.30
25	8.00	7.80	8.45	10.45	13.10	10.40	8.10	7.55	7.95	9.70	8.70	8.40
26	7.85	8.15	8.45	10.30	13.50	10.40	8.00	7.50	8.00	9.70	8.70	8.30
27	7.70	7.90	8.60	10.50	13.55	10.40	8.00	7.50	8.00	9.90	8.70	8.30
28	7.70	8.00	8.80	10.75	13.90	10.30	7.85	7.55	8.00	10.15	8.70	8.30
29	7.70	.....	8.95	10.85	14.00	10.20	7.80	7.60	8.10	9.90	8.70	8.30
30	7.70	.....	9.00	10.75	13.80	10.85	7.75	7.60	8.10	9.60	8.70	8.30
31	7.70	.....	8.85	.....	13.80	.....	7.65	7.60	.....	9.50	.....	8.40

ABIQUIU STATION ON CHAMA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 252, is located about 200 yards above the town of Abiquiu, New Mexico. The gage consists of two pieces of 4 by 4 inch timbers laid on the slope of the river bank and spiked to hand-driven piles. The gaging equipment consists of five-eighths inch cable, car, and tagged wire. The initial point for soundings is on the left bank. The channel is straight, both above and below the station, for a distance of about 300 feet, although at stages of very low water it is likely to divide and swing in the main bed. The right bank is steep and rocky, but the left is liable to overflow during an excessive flood. The observer is Henry Grant. This station was discontinued on April 7, 1897. The following is a list of discharge measurements made during 1897 by P. E. Harroun:

February 26, gage height, 2.20 feet; discharge, 66 second-feet.
March 18, gage height, 3.00 feet; discharge, 318 second-feet.

Daily gage height, in feet, of Chama River at Abiquiu, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1...	3.40	2.10	2.35	4.15	12...	1.95	2.15	3.15	.....	23...	1.95	2.00	3.70	.....
2...	2.55	2.10	2.35	3.95	13...	1.90	2.00	3.00	.....	24...	2.00	1.95	4.05	.....
3...	2.40	2.05	2.50	4.20	14...	3.45	2.00	3.05	.....	25...	2.05	2.10	3.70	.....
4...	2.25	2.05	3.55	5.10	15...	3.25	2.00	2.90	.....	26...	2.15	2.05	3.70	.....
5...	2.20	2.00	3.55	4.85	16...	3.00	2.00	2.90	.....	27...	2.15	2.15	4.10	.....
6...	2.05	2.15	3.20	5.75	17..	2.45	2.00	3.15	.....	28...	2.05	2.25	4.05	.....
7...	1.90	2.05	2.90	4.85	18...	2.30	2.25	3.25	.....	29...	2.10	.....	4.10	.....
8...	2.05	2.15	3.05	.....	19...	2.20	2.40	3.15	.....	30...	2.10	.....	3.95	.....
9...	2.10	1.95	2.95	.....	20...	2.05	2.15	2.95	.....	31...	1.95	.....	3.85	.....
10...	2.05	2.00	2.80	.....	21...	2.00	2.05	3.05	.....					
11...	2.10	2.10	2.85	.....	22...	2.15	2.05	3.25	.....					

RIO GRANDE STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 252, is located about one-fourth of a mile above the railroad station, Rio Grande, New Mexico. The equipment consists of a five-eighths inch wire cable, car, and tagged wire. The gage is inclined, and consists of two timbers 4 inches square fastened to hand-driven piles and wired to solid rocks. The bench mark is on the top of a bowlder, to which the upper portion of the gage is fastened, and is 17.815 feet above gage datum. Measurements are made from the car suspended from the cable. The bed of the stream is rocky and is confined between high banks. The observer is L. M. Fewell. The following discharge measurements were made in 1897 by P. E. Harroun:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 25...	4.90	487	July 10....	5.90	1,757	Sept. 24..	5.20	637
Mar. 17...	5.83	1,003	July 23....	5.20	995	Oct. 7....	6.10	1,584
May 15...	10.50	10,892	Aug. 11....	4.80	406	Oct. 24...	7.00	2,712
June 9 ...	8.80	6,794	Aug. 28....	4.20	266			
June 22 ..	7.20	3,470	Sept. 12 ...	5.70	1,044			

Daily gage height, in feet, of Rio Grande at Rio Grande, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	4.95	5.20	6.10	9.50	10.50	6.50	4.70	4.40	5.40	6.20	5.15
2	4.75	4.95	5.25	6.10	10.00	10.50	6.30	4.55	4.20	5.45	6.20	5.15
3	4.70	5.10	5.90	6.00	10.35	10.20	6.10	4.00	4.45	5.40	6.20	5.05
4	4.65	5.10	6.30	6.05	10.90	10.20	6.00	4.90	4.30	5.50	6.20	4.80
5	4.35	4.95	5.40	6.00	10.55	9.70	6.00	4.70	4.20	7.40	6.20	4.80
6	4.30	5.00	5.15	6.60	9.95	9.25	6.00	4.90	4.20	6.35	6.10	4.80
7	4.85	5.00	5.15	7.25	9.80	9.00	5.90	4.80	4.80	6.25	6.00	4.05
8	4.75	5.00	5.22	7.40	10.05	8.90	5.90	4.80	4.50	6.60	5.90	5.20
9	4.70	4.95	5.80	6.85	10.40	8.80	5.80	4.80	5.05	7.00	5.80	5.20
10	4.85	5.00	5.70	6.80	10.55	8.90	6.15	4.80	5.45	7.55	5.75	5.30
11	5.00	5.00	5.55	7.10	10.85	9.00	6.20	4.80	5.35	7.20	5.70	5.30
12	5.05	4.90	5.40	7.25	10.60	9.10	6.20	4.80	5.70	7.15	5.75	5.35
13	5.00	5.00	5.40	7.40	10.50	9.20	6.05	5.15	5.90	7.10	5.80	4.80
14	4.90	5.05	5.35	7.40	10.50	9.25	6.00	4.55	6.70	7.00	5.80	4.80
15	5.05	4.90	5.20	7.75	10.45	9.20	6.10	4.50	5.60	6.90	5.90	4.70
16	5.05	4.82	5.62	8.25	10.55	8.95	6.20	4.30	5.20	6.80	5.90	4.80
17	4.85	4.90	5.85	8.30	10.40	8.60	7.00	5.85	4.95	6.70	5.80	5.20
18	4.70	4.95	5.65	8.70	10.30	8.35	7.00	5.25	5.00	7.05	5.80	5.00
19	4.65	5.00	5.60	8.95	12.35	8.20	6.35	5.00	5.05	7.10	5.70	4.95
20	4.60	5.05	5.65	9.15	12.25	7.70	5.95	4.70	5.10	7.00	5.70	5.00
21	4.70	5.10	5.50	9.30	11.70	7.45	5.65	4.60	5.10	6.85	5.70	4.95
22	4.65	4.90	5.55	9.25	11.60	7.25	5.35	5.25	5.10	6.70	5.70	4.70
23	4.80	4.85	5.35	9.45	11.25	7.05	5.20	4.85	5.20	6.55	5.60	4.50
24	4.80	4.90	5.25	9.15	10.80	6.95	5.20	4.75	5.30	6.55	5.60	4.80
25	4.80	4.95	5.45	9.10	10.60	6.85	5.10	4.65	5.30	6.50	5.60	4.90
26	4.85	5.05	5.75	9.20	10.90	6.50	4.95	4.50	5.30	6.50	5.60	4.80
27	4.85	5.06	6.35	9.80	10.90	6.65	4.75	4.30	5.35	6.50	5.60	4.85
28	4.70	5.05	6.40	9.82	11.00	6.75	4.60	4.20	5.50	6.40	5.60	4.90
29	4.70	.....	6.85	9.40	11.00	6.60	4.45	4.20	5.40	6.30	5.45	4.90
30	4.95	.....	6.80	9.40	10.90	6.55	4.40	5.25	5.40	6.30	5.25	5.00
31	5.00	.....	6.32	.....	11.20	.....	4.30	4.50	.....	6.30	.....	5.00

SAN MARCIAL STATION ON RIO GRANDE.

This station, as described in the Eighteenth Annual Report, Part IV, page 254, is located at the railway bridge one-half mile south of San Marcial, New Mexico. The wire gage is attached to the guard rail of the bridge, lower side, south span. Bench marks: The 13-foot mark is level with the extension of the pier to which the old gage was fastened; the 15-foot mark is level with the top of the capstone on which the bridge truss rests. The channel is sandy and shifting. Several bridge piers also break the current. The observer is H. C. Lohman. The following discharge measurements were made by P. E. Harroun in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 21	7.40	344	June 7	9.60	9,141	Aug. 18	5.20	5
Mar. 24	7.50	478	June 21	8.70	4,142	Aug. 26	5.60	23
Apr. 9	7.50	800	June 29	8.10	2,811	Sept. 4	5.10	7
Apr. 9	8.00	1,650	July 8	7.40	1,053	Sept. 19	8.00	4,276
Apr. 20	8.50	3,165	July 16	7.70	1,150	Oct. 3	7.00	816
May 5	10.20	8,679	July 30	7.00	401	Oct. 15	8.10	3,980
May 19	10.00	10,403	Aug. 9	6.60	188	Oct. 28	8.10	3,796

Daily gage height, in feet, of Rio Grande at San Marcial, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.50	7.40	7.50	8.50	9.50	10.15	7.80	6.60	5.00	7.00	8.00	7.90
2	7.50	7.40	7.50	8.20	9.50	10.05	7.90	6.60	5.00	7.00	8.00	7.80
3	7.50	7.40	7.50	7.60	9.50	10.00	7.95	6.40	5.10	6.90	8.00	7.70
4	7.40	7.40	7.50	7.60	9.80	9.75	7.60	6.30	5.10	6.90	7.90	7.70
5	7.40	7.40	7.50	7.60	10.25	9.80	7.60	6.65	7.60	8.45	7.90	7.70
6	7.40	7.40	7.50	7.60	10.65	9.60	7.50	6.90	7.75	9.40	8.00	7.80
7	7.40	7.40	7.50	7.60	11.20	9.50	7.50	6.60	7.10	8.55	8.00	7.90
8	7.40	7.40	7.50	7.60	10.75	9.25	7.40	6.95	6.80	8.10	8.00	7.70
9	7.40	7.40	7.50	7.90	10.50	9.05	7.60	6.55	6.35	8.25	7.90	7.70
10	7.40	7.40	7.50	8.00	10.50	9.00	7.70	6.25	6.80	11.00	8.00	7.70
11	7.40	7.40	7.50	8.30	10.50	9.00	7.80	6.00	6.40	9.15	8.00	7.70
12	7.25	7.40	7.50	8.30	10.50	9.15	7.55	6.00	6.85	8.65	7.80	7.70
13	7.25	7.40	7.50	8.30	10.50	9.20	7.85	5.90	8.30	8.40	7.60	7.70
14	7.25	7.40	7.45	8.60	10.50	9.25	7.60	5.90	8.50	8.30	7.60	7.70
15	7.12	7.40	7.55	8.95	10.50	9.20	7.55	5.85	7.75	8.20	7.60	7.80
16	7.00	7.40	7.65	8.50	10.50	9.00	7.50	5.70	7.65	8.10	7.60	7.80
17	7.00	7.48	7.50	8.50	10.50	9.00	7.50	5.60	7.50	8.00	7.80	7.70
18	7.00	7.45	7.40	8.50	10.50	8.95	7.50	5.30	7.20	8.00	7.80	7.70
19	7.00	7.45	7.40	8.50	10.50	9.00	7.80	5.20	7.65	8.00	7.90	7.70
20	7.00	7.45	7.40	8.65	11.55	8.90	7.70	5.85	7.00	8.20	7.90	7.70
21	7.00	7.45	7.40	9.15	12.35	8.70	7.50	5.90	6.80	8.30	7.90	7.70
22	7.00	7.50	7.48	9.40	12.35	8.55	7.40	5.85	6.80	8.40	7.90	7.70
23	7.00	7.50	7.50	9.75	11.70	8.40	7.40	5.70	6.80	8.30	7.90	7.70
24	7.00	7.50	7.50	9.50	10.00	8.20	7.40	5.60	7.00	8.20	7.80	7.70
25	7.30	7.50	7.80	9.50	10.00	8.15	7.30	5.75	7.70	8.20	7.80	7.70
26	7.30	7.50	7.65	9.50	10.00	8.00	7.30	5.70	8.25	8.20	7.80	7.70
27	7.30	7.50	7.60	9.50	10.00	7.85	7.30	5.65	8.15	8.20	7.80	7.70
28	7.32	7.50	7.60	9.50	10.00	8.40	7.30	5.65	7.65	8.10	7.80	7.70
29	7.40	.....	7.60	9.50	10.00	8.00	7.15	5.55	7.35	8.10	7.80	7.70
30	7.40	.....	7.60	9.50	10.80	7.85	7.00	5.35	7.00	8.20	7.90	7.70
31	7.40	.....	7.70	.....	10.60	.....	6.80	5.00	.....	8.20	.....	7.70

EL PASO STATION ON RIO GRANDE.

This station, as described in the Eighteenth Annual Report, Part IV, page 259, was located at the pumping house of the smelter company 3 miles north of El Paso, Texas. The bed of the stream here is composed of mud, constantly shifting and changing. May 1, 1897, the station was placed under the charge of W. W. Follett, consulting engineer, International (Water) Boundary Commission, and by him removed 1 mile farther up the river to Courchesne's limekiln. The river heights are measured at the masonry pump foundation pier 150 feet above the kiln. The top of the downstream chisel draft on this pier was assumed to be at gage height 15.0 feet, and the distance of the surface of the water below it was measured with a carefully graduated rod. The left bank of the river is formed by the loose rock fill of the Atchison, Topeka and Santa Fe Railroad embankment, and will not overflow. The right bank, however, is not so good, being made ground and subject to overflow. The bottom of the river here has also proven unstable, scouring on a rise and filling on a falling river. It is probably the best site for a station in the vicinity of El Paso, however, as the entire river bed is constantly shifting for many miles above and below. On account of this shifting character of the stream, the only accurate method of estimating the daily discharges is by taking a large number of measurements, which was done in 1897 as follows, by P. E. Harroun, W. W. Follett, and T. M. Courchesne:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 22...	6.60	195	May 23....	13.40	8,816	June 21 ..	10.00	5,227
Mar. 25...	6.00	52	May 24....	13.70	10,088	June 23 ..	9.60	4,100
Apr. 10...	7.00	242	May 25....	14.10	10,421	June 25 ..	8.90	2,809
May 4....	11.40	5,355	May 26....	14.35	11,583	June 26 ..	8.40	2,474
May 5....	11.35	5,277	June 4	12.60	10,410	July 1....	10.40	5,617
May 7....	11.45	5,891	June 7	12.30	9,448	July 3....	9.60	3,931
May 8....	11.95	6,588	June 11 ...	10.70	7,175	July 6....	8.30	1,733
May 11...	12.50	7,241	June 12 ...	10.30	5,228	July 8....	7.60	976
May 12...	11.85	6,810	June 14 ...	10.20	4,980	July 10...	7.50	1,059
May 19...	12.20	7,407	June 16 ...	10.10	5,340	July 16...	7.90	1,288
May 21...	12.40	8,099	June 18 ...	10.10	5,424	July 17...	7.60	902
May 22...	12.80	9,803	June 19 ...	10.20	5,446	July 19...	7.50	865

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.ft.*		*Feet.*	*Sec.ft.*		*Feet.*	*Sec.ft.*
July 24...	6.90	716	Sept. 20 ...	8.20	1,042	Nov. 22...	8.00	1,033
July 26...	6.70	508	Sept. 23 ...	7.20	555	Nov. 25...	8.00	1,049
July 29...	6.40	385	Sept. 25 ...	6.60	317	Nov. 27...	7.90	999
July 31...	6.20	302	Sept. 27 ...	6.65	347	Nov. 29...	8.10	959
Aug. 2....	6.10	229	Sept. 29 ...	7.75	1,289	Dec. 1....	8.10	886
Aug. 4....	5.80	100	Oct. 2	7.50	599	Dec. 3....	7.80	917
Aug. 6....	5.70	68	Oct. 22	8.55	1,403	Dec. 6....	7.60	645
Aug. 9....	5.60	57	Oct. 25	8.80	1,463	Dec. 8....	7.50	534
Aug. 11...	5.50	50	Oct. 29	8.80	1,406	Dec. 11...	7.80	678
Aug. 13...	5.90	178	Nov. 1.....	8.90	1,654	Dec. 13...	7.30	503
Aug. 14...	5.80	130	Nov. 3.....	8.60	1,493	Dec. 15...	7.40	582
Aug. 17...	5.50	53	Nov. 6.....	8.40	1,332	Dec. 18...	7.80	687
Aug. 19...	7.00	495	Nov. 8.....	8.30	1,162	Dec. 20...	7.60	657
Aug. 22...	6.40	228	Nov. 10....	8.40	1,215	Dec. 22...	7.00	467
Sept. 10 ..	6.50	261	Nov. 13....	8.40	1,242	Dec. 24...	7.30	541
Sept. 12 ..	6.65	308	Nov. 15....	8.10	1,006	Dec. 27...	7.40	583
Sept. 14 ..	7.20	702	Nov. 17....	7.90	882	Dec. 29...	7.50	616
Sept. 16 ..	9.05	2,882	Nov. 19....	8.20	1,248			
Sept. 18 ..	8.60	1,892	Nov. 20....	8.10	1,034			

Daily gage height, in feet, of Rio Grande at El Paso, Texas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.60	6.90	6.30	6.05	a11.30	12.70	10.30	6.20	(b)	7.85	8.90	8.10
2	6.60	6.90	6.30	6.00	11.40	12.60	9.90	6.10	(b)	7.40	8.70	8.00
3	6.70	6.80	6.20	5.90	11.50	12.80	9.00	5.95	(b)	7.00	8.60	8.00
4	6.70	6.80	6.20	6.75	11.40	12.60	8.60	5.80	(b)	6.65	8.50	7.95
5	6.75	6.80	6.20	7.80	11.35	12.55	8.20	5.80	6.10	6.45	8.45	7.85
6	6.80	6.80	6.15	7.50	11.40	12.55	8.20	5.70	5.95	6.35	8.40	7.85
7	7.20	6.85	6.10	7.05	11.50	12.25	7.70	5.60	5.90	6.15	8.40	7.70
8	6.95	6.80	6.00	7.00	12.00	11.95	7.55	5.60	6.40	7.00	8.35	7.55
9	6.65	6.70	6.00	7.00	12.65	11.70	7.30	5.60	6.10	10.15	8.40	7.70
10	6.45	6.75	5.90	7.00	13.40	11.05	7.60	5.60	6.60	9.55	8.40	7.90
11	6.45	6.85	5.90	7.00	12.65	10.65	8.40	5.50	6.60	9.45	8.40	8.00
12	6.20	6.85	5.80	7.95	11.75	10.30	7.90	5.40	6.70	10.60	8.40	7.75
13	6.20	6.80	5.85	8.50	11.55	10.25	7.90	5.80	7.05	11.15	8.40	7.35
14	6.20	6.80	6.35	8.40	11.70	10.15	7.90	5.80	7.40	10.00	8.25	7.40
15	6.20	6.90	6.20	8.30	11.95	9.90	7.95	5.60	7.30	9.20	8.10	7.35
16	6.20	6.85	6.20	8.30	12.05	10.10	7.85	5.70	9.10	8.90	8.10	7.40
17	7.50	6.80	6.10	8.50	12.35	10.10	7.55	5.50	8.90	8.65	7.95	7.40
18	8.25	6.80	6.05	8.60	12.35	10.15	7.45	6.50	8.60	8.75	8.00	7.80
19	8.00	6.75	6.00	8.60	12.20	10.15	7.50	7.20	8.70	8.70	8.15	7.75
20	7.60	6.70	6.00	8.80	12.10	10.10	7.20	6.80	8.10	8.60	8.10	7.55
21	7.35	6.60	6.00	9.05	12.60	10.05	6.90	6.50	7.90	8.60	8.15	7.25
22	7.30	6.60	6.35	9.15	12.80	9.75	7.20	6.40	7.50	8.55	8.05	7.00
23	7.20	6.50	6.30	9.80	13.25	9.55	7.70	6.10	7.20	8.60	8.10	7.20
24	7.20	6.50	6.20	10.05	13.80	9.20	6.90	5.90	7.00	8.85	8.05	7.35
25	7.20	6.45	6.00	10.15	14.15	8.80	6.75	5.70	6.70	8.80	7.95	7.50
26	7.10	6.50	5.85	10.25	14.45	8.35	6.70	5.50	6.50	8.70	7.85	7.50
27	7.00	6.40	5.75	10.45	15.30	8.20	7.30	(b)	6.70	8.70	7.95	7.40
28	6.90	6.35	5.75	10.50	14.20	8.05	6.40	(b)	7.15	8.80	7.95	7.50
29	6.75	.....	5.60	10.45	13.35	8.05	6.30	(b)	7.85	8.80	8.10	7.60
30	6.80	.....	5.80	10.40	12.90	9.30	6.25	(b)	8.35	8.90	8.00	7.35
31	6.80	.....	6.00	.....	12.70	.....	6.20	(b)	.....	8.70	.....	7.20

a Location of gaging station changed. b No flow.

GRANGER STATION ON BLACKS FORK.

The old station, described in the Eighteenth Annual Report, Part IV, page 270, was located 3 miles west of Granger, Wyoming, at the Union Pacific railroad bridge, and above Hams Fork. On April 28 the location was abandoned and the station was removed to a point below Hams Fork, about one-fourth of a mile below Granger. The new rod consists of a horizontal timber 4 by 4 inches by 16 feet, fastened to two upright posts 6 feet apart and set firmly in the bank of the river above high-water mark. One end of this horizontal timber, to which the wire gage is fastened, projects out over the water. The length of the gage wire is 13.35 feet. The distance from the outside edge of the pulley to the zero of the rod is 2.45 feet. The bench mark is a rail spike in an old tie 24 feet southwest of inside post of gage. The letters "B. M." are marked in black paint on the tie. The elevation of the head of the spike above datum is 8.74 feet. The observer, pump man for the railroad, is J. R. Kirby. Discharge measurements are made from a cable and car 400 feet below the rod. The following are those made in 1897, by C. T. Johnston:

May 7, gage height, 4.55 feet; discharge, 3,724 second-feet.
May 18, gage height, 4.60 feet; discharge, 4,079 second-feet.
May 26, gage height, 5.10 feet; discharge, 4,976 second-feet.
June 3, gage height, 3.60 feet; discharge, 2,910 second-feet.
June 10, gage height, 2.75 feet; discharge, 1,758 second-feet.
June 15, gage height, 2.45 feet; discharge, 1,432 second-feet.
August 9, gage height, 0.40 foot; discharge, 222 second-feet.

Daily gage height, in feet, of Blacks Fork at Granger, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	3.00	2.80	4.00	1.00	0.20	—0.10	0.65	.....	.....
2	2.90	.....	.....	3.20	3.05	3.85	1.00	.20	— .10	1.50	.....	.....
3	.....	.....	.....	2.90	3.20	3.50	1.05	.20	— .10	.....	.....	.....
4	.....	.....	.....	3.20	3.35	3.20	1.20	.30	— .10	.....	.....	0.80
5	.....	.....	.....	3.20	3.70	2.90	1.15	.30	+ .05	.....	.....	.....
6	.....	2.90	2.90	2.90	4.20	2.65	1.05	.30	.00	.....	.....	.....
7	.....	.....	.....	a3.60	4.55	2.50	.95	.35	.00	.....	0.60	.....
8	.....	.....	.....	3.40	4.95	2.40	.90	.40	.00	.....	.....	.....
9	2.90	.....	.....	3.20	5.10	2.50	.85	.40	.00	.90	.....	.....
10	.....	.....	.....	3.50	4.95	2.65	.80	.40	.00	.....	.....	.....
11	.....	.....	.....	5.50	4.60	2.70	.70	.40	.00	.....	.....	1.20
12	.....	.....	.....	4.60	4.10	2.50	.70	.40	.00	.....	.....	.....
13	.....	2.90	2.90	4.20	3.85	2.30	.60	.35	.00	.....	.60	.....
14	.....	.....	.....	3.70	4.10	2.40	.60	.30	.10	.....	.....	.....
15	.....	.....	.....	3.50	4.25	2.30	.60	.30	.10	.....	.....	.....
16	2.90	.....	.....	3.90	4.50	2.25	.60	.30	.20	.80	.....	.....
17	.....	.....	.....	4.20	4.55	2.05	.60	.20	.30	.....	.....	.....
18	.....	.....	.....	4.40	4.60	2.05	.60	.20	.30	.....	.....	.....
19	.....	.....	2.90	4.60	4.50	1.75	.60	.10	.30	.....	.....	1.10
20	.....	2.90	.....	4.60	4.55	1.60	.55	.10	.25	.....	.50	.....
21	.....	.....	.....	4.50	5.05	1.45	.50	.10	.20	.....	.....	.....
22	.....	.....	.....	4.20	5.30	1.40	.50	.10	.20	.....	.....	.....
23	2.90	.....	.....	3.60	5.30	1.40	.50	.10	.20	.60	.....	.....
24	.....	.....	.....	3.30	5.60	1.30	.50	.05	.20	.....	.....	.....
25	.....	.....	.....	3.30	5.40	1.20	.40	.00	.20	.....	.....	1.10
26	.....	.....	.....	3.20	4.95	1.20	.40	.00	.25	.....	.....	.....
27	.....	2.90	2.90	3.50	4.70	1.10	.35	.00	.35	.....	.....	.....
28	.....	.....	.....	b1.90	4.35	1.05	.30	.00	.40	.....	.....	.....
29	.....	.....	.....	2.30	4.20	1.10	.30	.00	.50	.....	.....	.....
30	2.90	.....	.....	2.50	4.20	1.10	.20	.00	.50	.....	.....	.....
31	.....	.....	.....	.....	4.05	.....	.20	.00	.....	.....	.....	.....

a New wire gage.
b Station moved to one-fourth mile below Granger, Wyoming.

GREENRIVER STATION ON GREEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 272, is located at Greenriver, Wyoming. The rod is fastened to an old pile near the east end of the bridge at the pump house of the railroad company. The pumpman in charge, William Slater, is the observer. The bench mark consists of a cross on the third step from the bottom on the south end of east abutment, and is 12.48 feet above datum. The section under the railroad bridge is poor, and discharge measurements are made from the new iron highway bridge one-half mile below. The channel here is straight for some distance above and below. The banks are medium high, and the bed is composed of small cobblestones and gravel, being quite permanent in character. The following discharge measurements were made by Cyrus C. Babb and C. T. Johnston in 1897:

April 27, gage height, 1.85 feet; discharge, 1,820 second-feet.
May 7, gage height, 3.30 feet; discharge, 6,970 second-feet.
May 18, gage height, 4.00 feet: discharge, 9,325 second-feet.
May 26, gage height, 5.35 feet; discharge, 15,318 second-feet.
June 3, gage height, 5.10 feet; discharge, 14,896 second-feet.
June 10, gage height, 3.45 feet; discharge, 6,104 second-feet.
June 15, gage height, 3.60 feet; discharge, 7,094 second-feet.
August 9, gage height, 2.00 feet; discharge, 2,081 second-feet.

Daily gage height, in feet, of Green River at Greenriver, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	.....	1.88	2.35	4.80	2.85	1.85	1.10	1.00	1.25
2	.....	.....	.....	1.75	2.50	4.92	2.75	1.95	1.05	1.32	.....
3	1.80	.....	.....	1.55	2.55	5.08	2.75	2.02	1.00	.....	1.25
4	.....	.....	.....	1.50	2.72	4.80	2.85	2.25	0.98	.....	.....
5	.....	2.20	2.15	1.58	2.95	4.40	3.00	2.22	.95	.....	1.20
6	.....	2.20	2.15	1.52	3.15	4.12	2.92	2.18	.95	.....	.....
7	.....	.....	.....	1.50	3.32	3.82	2.75	2.08	1.00	.....	.....
8	1.80	.....	.....	1.52	3.45	3.55	2.65	2.10	1.00	.....	1.20
9	1.80	.....	.....	1.48	3.68	3.48	2.58	2.02	.95	.....	.....
10	.....	.....	.....	1.45	3.65	3.58	2.50	2.10	1.00	.....	1.20
11	.....	.....	.....	1.55	3.58	3.68	2.50	2.05	1.00	1.35	.....
12	1.80	2.10	2.15	1.72	3.50	3.72	2.50	1.98	1.00	.....	1.20
13	.....	2.10	.....	1.78	3.38	3.65	2.45	1.88	1.00	1.30	.....
14	.....	.....	2.15	1.95	3.38	3.65	2.40	1.82	.95	.....	.....
15	.....	.....	.....	2.00	3.50	3.68	2.32	1.80	.95	1.25	1.20
16	1.80	.....	.....	2.05	3.68	3.75	2.30	1.80	.95	.....	.....
17	.....	.....	.....	2.15	3.88	3.75	2.25	1.75	.90	.....	1.20
18	1.80	2.10	.....	2.30	4.02	3.80	2.30	1.68	.90	1.80	.....
19	.....	.....	2.15	2.25	4.10	3.75	2.25	1.58	.90	.....	1.15
20	.....	2.10	2.15	2.35	4.25	3.55	2.25	1.50	.90	1.60	.....
21	.....	.....	.....	2.40	4.62	3.35	2.22	1.45	.90	.....	.....
22	1.90	.....	.....	2.50	5.30	3.12	2.18	1.40	.90	1.20	.....
23	.....	.....	.....	2.40	5.85	3.05	2.12	1.40	.90	.....	.....
24	1.90	.....	.....	1.85	5.58	3.00	2.10	1.35	.90	.....	.....
25	.....	.....	.....	1.78	5.42	2.98	2.02	1.32	.90	1.25	.....
26	.....	2.15	2.40	1.80	5.32	3.02	1.98	1.28	.95	.....	.....
27	.....	2.15	2.40	1.98	5.28	3.00	1.95	1.25	.95	1.30	.....
28	.....	.....	.....	2.05	5.15	3.00	1.90	1.20	.95	.....	.....
29	2.00	.....	.....	2.22	4.88	3.00	1.90	1.20	1.00	1.30	.....
30	2.00	.....	.....	2.35	4.60	2.98	1.85	1.15	1.00	.....	.....
31	.....	.....	.....	.....	4.62	.....	1.80	1.12	.....	.....	.....

BLAKE STATION ON GREEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 275, is located at the crossing of the Rio Grande Western Railroad at Blake, Utah. The elevation of the top of the pier, to which the old vertical rod is attached, is 22.00 feet above the rod datum. The rod of the wire gage is nailed to the guard rail on the lower side of the bridge. The distance from the end of the rod to the outside edge of the pulley wheel is 1 foot; from the end of the weight to the wire index marker, 27.67 feet. The observer is Frank Jacobs, rancher. The section at this point is good, the channel being straight for some distance above and below. The bed is gravelly. The initial point for soundings is on the right bank. The following discharge measurements were made in 1897 by Cyrus C. Babb and W. B. Dougall:

April 21, gage height, 4.88 feet; discharge, 8,175 second-feet.
May 22, gage height, 10.10 feet; discharge, 55,886 second-feet.
November 22, gage height, 2.80 feet; discharge, 3,373 second-feet.

Daily gage height, in feet, of Green River at Blake, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	6.75	10.55	5.55	3.30	2.30	3.95	3.20	2.60
2	1.70	.....	.....	.....	7.05	10.25	5.35	3.30	2.20	4.50	3.20	2.50
3	.....	.....	.....	3.70	7.40	10.20	5.15	3.20	2.20	4.50	3.15	2.40
4	.....	.....	.....	3.70	7.80	10.00	5.15	3.10	2.35	4.50	3.10	2.30
5	.....	.....	.....	3.60	8.25	10.00	5.25	3.20	2.20	4.30	3.10	2.20
6	.....	1.80	2.00	3.75	8.70	9.95	5.20	3.30	2.35	4.15	3.00	2.10
7	.....	.....	.....	3.65	8.90	9.15	5.00	3.40	2.40	4.05	3.00	2.00
8	.....	.....	.....	3.50	9.05	8.60	4.90	3.50	2.55	4.35	3.00	1.90
9	1.70	.....	.....	3.50	9.25	8.20	4.80	3.50	2.70	4.55	2.90	1.90
10	.....	.....	.....	3.60	9.45	7.90	4.70	3.40	2.85	4.85	2.90	1.90
11	.....	.....	.....	3.70	9.65	7.60	4.60	3.40	3.25	4.75	2.90	1.90
12	.....	.....	.....	3.55	9.90	7.50	4.50	3.40	4.70	4.60	2.80	1.80
13	.....	1.90	.....	3.55	9.95	7.80	4.40	3.45	4.70	4.50	2.80	1.80
14	.....	.....	.....	3.70	9.85	7.70	4.30	3.50	5.30	4.35	2.80	1.70
15	.....	.....	2.00	3.95	9.25	7.80	4.20	3.50	3.70	4.10	2.80	1.70
16	1.80	.....	.....	4.15	9.15	7.70	4.10	3.40	3.40	3.85	2.80	1.60
17	.....	.....	.....	4.35	9.35	7.60	4.10	3.30	3.30	3.80	2.80	1.50
18	.....	.....	.....	4.50	9.55	7.50	4.10	3.15	2.90	3.70	2.80	1.40
19	.....	.....	.....	4.60	9.75	7.35	4.00	3.05	2.80	3.70	2.80	1.40
20	.....	1.90	2.10	4.60	9.95	7.25	4.00	2.90	2.80	3.60	2.80	1.30
21	.....	.....	.....	4.75	10.05	7.10	3.90	2.85	2.70	3.60	2.80	1.40
22	.....	.....	.....	5.60	10.05	6.95	3.90	2.70	2.60	3.50	2.80	1.30
23	1.60	.....	.....	5.45	10.05	6.75	3.80	2.70	2.50	3.50	2.80	1.20
24	.....	.....	.....	6.15	10.25	6.55	3.80	2.60	2.50	3.40	2.80	1.20
25	.....	.....	.....	6.30	10.60	6.35	3.80	2.60	2.50	3.50	2.80	1.10
26	.....	.....	.....	5.80	11.00	6.25	3.70	2.50	2.50	3.55	2.80	1.20
27	.....	1.95	2.90	5.70	11.25	6.15	3.60	2.50	2.65	3.45	2.80	1.30
28	.....	.....	.....	5.70	11.35	6.35	3.50	2.40	2.85	3.40	2.80	1.25
29	.....	.....	3.90	5.95	11.40	5.95	3.50	2.40	3.05	3.40	2.80	1.35
30	1.60	.....	.....	6.30	11.15	5.75	3.50	2.40	3.35	3.30	2.70	1.40
31	.....	.....	.....	.....	10.95	.....	3.40	2.40	.....	3.20	.....	1.30

SHOSHONE STATION ON GRAND RIVER.

This station is located at Shoshone, or Gypsum post-office, Colorado, on the line of Denver and Rio Grande Railroad, 10 miles east of Glenwood Springs, Colorado. The rod is a vertical 3 by 6 inch wooden timber set 3 or 4 feet into rock and well braced. Observations are taken by the station agent, George Ruark, under the direction of the division superintendent of the railroad company. No discharge measurements were made at this point in 1897.

Daily gage height, in feet, of Grand River at Shoshone, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	4.10	13.40	6.55	1.55	17	10.35	11.40	4.00	(a)
2	5.15	13.35	6.60	1.55	18	10.90	10.25	4.00	(a)
3	5.70	12.50	7.00	1.90	19	11.05	9.35	3.60	(a)
4	6.95	10.25	6.90	2.50	20	11.10	9.25	3.50	(a)
5	7.15	9.50	6.50	2.70	21	11.45	9.50	3.00	(a)
6	8.20	8.50	5.35	2.95	22	11.00	9.35	2.45	(a)
7	8.90	8.30	4.85	2.55	23	11.75	9.95	2.50	(a)
8	9.90	7.55	5.00	2.00	24	12.65	9.55	2.40	(a)
9	10.10	8.20	6.00	2.05	25	13.35	8.85	2.60	(a)
10	9.95	9.55	6.70	1.95	26	13.20	8.60	2.50	(a)
11	9.45	10.00	5.70	1.55	27	13.00	9.00	2.25	(a)
12	8.75	10.65	5.35	1.20	28	12.85	8.60	2.20	(a)
13	8.60	11.40	4.70	1.10	29	12.95	7.55	1.75	(a)
14	9.90	11.60	4.45	1.10	30	13.25	7.05	1.80	(a)
15	9.35	11.55	4.40	1.00	31	13.30	.....	1.60	(a)
16	10.05	11.85	4.35	.90					

a Below gage.

GRAND JUNCTION STATION ON GRAND RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 260, is located at the wagon bridge across the Grand River, near the pump house of the city waterworks, Grand Junction, Colorado. The river at this point discharges through two channels. Gage rod No. 1 consists of a vertical 4 by 6 inch timber, with 1 by 6 inch scale, bolted to the bridge abutment on right-hand side of the right channel. The 12-foot mark is on a level with the top of the bridge abutment. The banks of the right channel are both liable to overflow at very high water; the bed is of sand, and the current very sluggish. The horizontal wire gage No. 2 is fastened to the upper side of the bridge over the left channel between marks 595 and 605 feet. The distance from the end of the weight to outer end of snap is 31.80 feet. The bench mark is a cross on iron post of bridge at 592 foot mark, and is 31.0 feet above datum. The right bank of the left channel is low and liable to overflow, the left is high and rocky; the bed is sandy; the water is deep and moves with considerable velocity. At high water it becomes necessary to guy the meter to a wire stretched across the channel above the bridge to prevent it from being swept down stream by the swift current. The observer is B. W. Vedder, engineer at the pumping station. The following measurements were made in 1897 by C. C. Babb and F. Cogswell in Channel No. 1:

April 20, gage height, 1.75 feet; discharge, 1,157 second-feet.
May 18, gage height, 4.80 feet; discharge, 10,927 second-feet.
July 29 to November 23 the channel was dry.

The following measurements were made in Channel No. 2:

April 20, gage height, 5.60 feet; discharge, 4,019 second-feet.
May 19, gage height, 10.20 feet; discharge, 21,759 second-feet.
July 29, gage height, 5.35 feet; discharge, 4,044 second-feet.
September 29, gage height, 4.05 feet; discharge, 2,062 second-feet.
October 28, gage height, 3.98 feet; discharge, 1,764 second-feet.
November 23, gage height, 3.90 feet; discharge, 1,423 second-feet.

Daily gage height, in feet, of Grand River at Gage No. 1, Grand Junction, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	0.00	2.60	5.10	1.45	17	1.00	4.55	3.80	.00
2	.00	2.90	5.25	1.25	18	1.25	4.70	3.40	.00
3	.00	3.25	4.65	1.35	19	1.55	4.95	2.85	.00
4	.00	3.50	3.75	1.65	20	1.80	4.75	2.55	.00
5	.00	3.80	2.85	1.50	21	1.85	4.60	2.65	.00
6	.00	4.15	2.50	.90	22	1.75	4.80	2.75	.00
7	.00	4.35	2.35	.65	23	1.60	4.85	2.85	.00
8	.00	4.70	2.20	.70	24	1.45	5.10	2.75	.00
9	.00	4.90	2.15	.90	25	1.50	5.35	2.40	.00
10	.00	4.75	2.80	1.15	26	1.65	5.30	2.10	(a)
11	.00	4.50	3.05	1.05	27	2.15	5.25	2.15	(a)
12	.00	4.35	3.40	1.00	28	2.40	5.00	2.15	(a)
13	.00	4.30	3.70	.50	29	2.40	4.90	1.90	(a)
14	.00	4.35	4.00	.15	30	2.45	5.10	1.55	(a)
15	.50	4.40	4.10	.00	31	.....	5.10	.....	(a)
16	.70	4.45	4.00	.00					

a Dry for rest of year.

Daily gage height, in feet, of Grand River at Gage No. 2, Grand Junction, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	3.50	6.75	10.30	7.95	5.10	4.00	4.00	3.85	3.90
2	2.80	.....	.....	3.60	7.20	10.55	7.75	5.15	4.00	4.00	3.90	3.90
3	.....	3.00	3.30	3.50	7.65	10.10	7.85	5.55	4.00	4.00	3.90	3.90
4	.....	.....	.....	3.40	7.90	9.30	8.15	5.75	4.00	4.00	3.90	3.70
5	.....	.....	.....	3.45	8.20	8.40	8.05	5.80	4.00	4.10	3.90	.....
6	.00	3.10	3.20	3.50	8.55	9.35	7.45	5.90	3.90	4.00	4.05	.....
7	.....	.....	.....	3.75	8.75	9.15	7.15	5.85	3.90	4.20	4.10	.....
8	.00	.....	.....	3.55	9.10	9.00	7.15	5.60	4.10	4.10	4.10	3.80
9	.....	.....	.....	3.60	9.45	8.95	7.45	5.40	4.10	4.20	4.05	.....
10	.....	.....	3.20	3.50	9.25	9.40	7.70	5.40	4.00	4.30	4.00	.....
11	.....	3.00	.....	3.60	9.00	9.75	7.75	5.30	4.20	4.20	3.85	3.80
12	.....	.....	.....	3.70	8.90	9.90	7.45	5.15	4.20	4.15	3.80	.....
13	.....	3.10	3.10	3.60	8.70	10.00	7.05	4.95	4.25	4.10	3.95	.....
14	3.00	.....	.....	3.80	8.85	10.30	6.75	4.90	4.70	4.10	4.10	.....
15	.....	.....	.....	3.90	8.90	10.35	6.65	4.90	4.45	4.10	4.10	3.80
16	3.10	.....	.....	4.10	8.95	10.25	6.60	4.75	4.25	4.10	4.00	.....
17	.....	3.10	3.40	4.55	9.10	9.95	6.60	4.60	4.10	4.50	3.90	.....
18	.....	.....	.....	4.85	9.20	9.75	6.45	4.55	4.00	4.35	3.80	3.70
19	.....	.....	.....	5.25	10.20	9.40	6.40	4.40	4.00	4.15	3.80	.....
20	.....	3.20	3.60	5.50	10.10	9.25	6.30	4.30	4.00	4.10	3.80	.....
21	2.90	.....	.....	5.65	10.00	9.20	6.15	4.30	4.00	4.00	3.95	.....
22	.....	.....	.....	5.55	10.20	9.25	5.95	4.20	4.00	4.00	3.90	3.70
23	3.00	.....	.....	5.40	10.25	9.35	5.75	4.10	4.00	4.00	3.90	.....
24	.....	3.10	3.00	5.15	10.50	9.25	5.70	4.10	3.95	4.00	3.90	.....
25	.....	.....	.....	5.20	10.70	9.00	5.60	4.05	3.90	4.10	4.10	3.80
26	.....	.....	.....	5.45	10.60	8.85	5.60	4.00	3.95	4.10	4.00	.....
27	.00	3.00	4.20	6.15	10.50	9.05	5.60	4.00	4.00	4.00	3.90	.....
28	.....	.....	.....	6.45	10.20	8.85	5.55	4.00	4.00	4.00	3.80	.....
29	.....	.....	.....	6.50	10.10	8.50	5.35	4.00	4.00	3.90	3.65	3.90
30	.00	.....	.....	6.55	10.20	8.20	5.25	4.00	4.00	3.80	3.75	.....
31	.....	.....	.....	.....	10.35	.....	5.10	4.00	.....	3.80	.....	.....

FORT CRAWFORD STATION ON UNCOMPAHGRE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 265, is located about one-half mile east of the depot at Fort Crawford, Colorado, at a wagon bridge, and is about 8 miles above Montrose. The gage consists of an inclined 4 by 4 inch timber, bolted to the bridge bent on the right-hand side of the stream. The bench mark consists of a spike driven in the base of a cottonwood post, and is 9.18 feet above zero. Both banks are low and liable to overflow at high water, and the bed of the stream is composed of sand and gravel. The observer is Mrs. F. Humphrey; post-office, Uncompahgre, Colorado. The following discharge measurements were made during 1897 by F. Cogswell.

April 18, gage height, 3.90 feet; discharge, 487 second-feet.
May 10, gage height, 4.55 feet; discharge, 884 second-feet.
June 21, gage height, 5.05 feet; discharge, 1,081 second-feet.
July 19, gage height, 4.50 feet; discharge, 473 second-feet.
August 23, gage height, 3.45 feet; discharge, 70 second-feet.
September 20, gage height, 3.85 feet; discharge, 153 second-feet.
October 18, gage height, 4.00 feet; discharge, 195 second-feet.

Daily gage height, in feet, of Uncompahgre River at Fort Crawford, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.15	4.05	4.50	4.50	4.00	3.35	4.35	3.95
2	3.15	4.15	4.40	4.60	4.20	3.40	4.15	3.90
3	2.95	4.25	4.05	5.35	4.10	3.40	4.05	3.90
4	3.05	4.40	3.95	4.70	3.95	3.40	4.00	3.90
5	3.20	4.40	4.05	4.65	4.15	3.45	4.00	3.90
6	3.20	4.50	4.00	4.65	4.05	3.45	4.15	3.85
7	3.30	4.50	4.10	4.70	4.20	3.55	4.15	3.85
8	3.28	4.45	4.65	4.85	4.00	3.40	4.15	3.80
9	3.25	4.40	5.00	4.95	4.00	3.60	4.05	3.80
10	3.25	4.45	5.00	4.85	3.85	3.45	4.05	3.70
11	3.25	4.20	4.85	4.70	3.95	3.40	4.05	3.65
12	3.30	4.45	4.80	4.65	4.00	3.55	4.00	3.70
13	3.32	4.30	5.10	4.65	3.85	3.85	4.00	3.75
14	3.50	4.25	5.30	4.60	3.80	4.10	4.05	3.70
15	3.60	4.35	5.40	4.65	3.85	4.05	4.20	3.75
16	3.80	4.20	5.35	4.50	3.85	4.05	4.05	3.80
17	3.90	4.15	5.05	4.45	3.75	3.85	4.00	3.65
18	4.10	4.45	5.05	4.50	3.60	3.80	4.00	3.75
19	4.20	4.40	4.90	4.45	3.60	3.85	4.10	3.70
20	4.05	4.40	4.95	4.10	3.55	3.90	4.00	3.65
21	3.95	4.50	5.00	4.30	3.50	4.05	4.00	3.60
22	3.75	4.35	5.15	4.45	3.50	4.00	3.90	3.60
23	3.60	4.45	5.40	4.45	3.45	3.95	3.80	3.65
24	3.65	4.65	5.20	4.35	3.45	4.00	3.90	3.65
25	4.10	4.55	5.05	4.45	3.40	3.95	3.90	3.60
26	4.00	4.85	5.15	4.15	3.40	4.15	4.00	3.65
27	4.15	4.90	5.00	4.15	3.35	4.15	3.85	3.65
28	4.30	4.20	4.55	4.25	3.35	3.95	3.85	.....
29	4.30	5.00	4.90	3.85	3.40	4.05	3.85	.....
30	4.40	5.00	5.00	4.00	3.40	4.20	3.90	.....
31	.....	4.95	.....	4.00	3.40	.....	3.90	.....

ROUBIDEAU AND WHITEWATER STATIONS ON GUNNISON RIVER.

Gage heights at these stations are reported daily by telegraph to the division superintendent of the Denver and Rio Grande Railroad Company at Salida, Colorado, who has kindly furnished this office with copies of same.

Roubideau station is at the railroad bridge at Roubideau, Colorado, 6 miles west of Delta. The observer is M. J. Johnston, track foreman.

Whitewater station is located 13 miles southeast of Grand Junction at Whitewater, Colorado. The gage is a vertical rod graduated to feet and halves and securely fastened on the right bank of the river. The observer is James Page, station agent. No measurements of discharge have been made at these stations.

Daily gage height, in feet, of Gunnison River at Roubideau, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1..	3.75	4.65	1.60	0.15	12...	4.50	3.60	1.25	0.15	23...	4.50	2.85	0.50	(a)
2..	4.25	5.15	1.50	.15	13...	4.75	3.85	1.15	.15	24...	4.75	2.85	.50	(a)
3..	4.50	4.50	1.75	.15	14...	4.75	4.25	1.15	.15	25...	5.00	2.75	.25	(a)
4..	4.00	3.75	1.75	.15	15...	4.85	4.00	1.00	.15	26...	4.90	2.25	.25	(a)
5..	4.50	3.25	1.50	.15	16...	4.75	4.00	.85	.15	27...	4.85	2.35	.25	(a)
6..	5.25	2.85	1.35	.15	17...	4.50	3.75	.85	.15	28...	4.75	2.35	.15	(a)
7..	5.50	2.75	1.25	.15	18...	4.40	3.25	.85	.15	29...	4.40	2.00	.25	(a)
8..	5.75	2.85	1.25	.15	19...	4.60	2.75	.85	.15	30...	4.60	1.75	.50	(a)
9..	5.75	3.00	1.25	.15	20...	4.50	2.65	.65	(a)	31...	4.50	.....	.15	(a)
10..	5.50	3.50	1.25	.15	21...	4.40	2.85	.65	(a)					
11..	5.00	3.60	1.25	.15	22...	4.35	2.75	.50	(a)					

a Below gage.

Daily gage height, in feet, of Gunnison River at Whitewater, Colorado, for 1897.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1....	4.40	5.35	1.00	12.....	5.50	4.00	(a)	23.....	5.00	3.00	(a)
2....	4.60	5.75	1.00	13.....	5.60	4.15	(a)	24.....	5.25	3.00	(a)
3....	4.85	5.25	1.00	14.....	5.65	4.35	(a)	25.....	5.60	3.00	(a)
4....	4.65	4.50	1.00	15.....	5.60	4.35	(a)	26.....	5.50	2.75	(a)
5....	4.90	3.85	.65	16.....	5.50	4.35	(a)	27.....	5.50	2.35	(a)
6....	5.60	3.60	.65	17.....	5.40	4.40	(a)	28.....	5.50	2.55	(a)
7....	5.90	3.35	.50	18.....	5.15	3.75	(a)	29.....	5.15	2.50	(a)
8....	6.35	3.15	.40	19.....	5.35	3.30	(a)	30.....	5.15	1.60	(a)
9....	6.25	3.40	.35	20.....	5.35	3.00	(a)	31.....	5.35	.....	(a)
10....	6.10	3.75	.35	21.....	5.00	3.00	(a)				
11....	5.75	4.00	(a)	22.....	5.00	3.00	(a)				

a Below gage.

GRAND JUNCTION STATION ON GUNNISON RIVER.

This station is located at the iron highway bridge 1.5 miles from the town of Grand Junction, Colorado. The gage is vertical and consists of a 2 by 6 inch timber bolted to the stone pier of the bridge. The top of the capstone is 17.60 feet above gage datum. The channel above the station is curved, but below it is nearly straight. The right bank is low and liable to overflow, but the left is high and rocky with still water at low stages. The observer is A. Lindquist, engineman at the Denver and Rio Grande Railroad Company's pump house. The following discharge measurements were made in 1897 by Cyrus C. Babb and F. Cogswell:

April 20, gage height, 4.60 feet; discharge, 5,975 second-feet.
May 20, gage height, 7.30 feet; discharge, 16,644 second-feet.
July 28, gage height, 2.65 feet; discharge, 1,814 second-feet.
September 28, gage height, 2.40 feet; discharge, 1,246 second-feet.
October 27, gage height, 2.50 feet; discharge, 1,270 second-feet.
November 23, gage height, 2.30 feet; discharge, 828 second-feet.

Daily gage height, in feet, of Gunnison River at Grand Junction, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.50	4.10	2.60	1.60	2.60	2.40	1.70
2	6.10	7.90	4.00	2.60	1.60	2.50	2.40	1.90
3	6.80	7.30	4.10	2.60	1.60	2.50	2.40	2.20
4	6.90	6.70	4.40	2.80	1.50	2.40	2.40	2.10
5	6.80	5.90	4.30	2.80	1.50	2.40	2.40	.....
6	7.30	5.70	4.10	2.80	1.60	2.40	2.40	.....
7	7.70	5.50	4.00	2.70	1.70	2.40	2.40	.....
8	8.10	5.40	4.00	2.60	1.70	2.50	2.30	.....
9	8.30	5.50	4.00	2.70	1.70	2.50	2.20	.....
10	8.10	6.00	4.30	2.70	1.70	2.70	2.10	.....
11	7.80	6.40	4.20	2.60	1.80	2.90	1.90	.....
12	7.40	6.60	4.00	2.50	1.80	2.80	2.10	.....
13	7.30	6.40	3.70	2.40	1.90	2.70	2.20	.....
14	7.40	6.70	3.50	2.30	2.00	2.60	2.40	.....
15	7.50	6.70	3.30	2.20	2.20	2.60	2.40	.....
16	7.60	6.70	3.30	2.20	2.20	2.70	2.30	.....
17	7.50	6.60	3.20	2.20	2.10	2.90	2.30	.....
18	7.10	6.00	3.20	2.10	2.10	2.80	2.10	.....
19	7.30	5.60	3.20	2.00	2.00	2.70	2.00	.....
20	7.40	5.40	3.20	2.00	2.00	2.70	2.10	.....
21	7.00	5.40	3.10	2.00	1.90	2.70	2.20	.....
22	7.00	5.40	3.00	1.90	2.00	2.60	2.10	.....
23	7.00	5.50	3.00	1.80	2.20	2.60	2.10	.....
24	7.30	5.50	2.90	1.70	2.20	2.60	2.30	.....
25	7.80	5.30	2.90	1.60	2.10	2.50	2.30	.....
26	7.60	5.20	2.90	1.60	2.10	2.50	2.20	.....
27	7.50	5.00	2.80	1.60	2.20	2.40	2.20	.....
28	7.50	4.90	2.70	1.50	2.30	2.40	2.00	.....
29	7.00	4.70	2.70	1.60	2.40	2.40	1.70	.....
30	7.30	4.40	2.70	1.60	2.60	2.30	1.60	.....
31	7.30	.....	2.60	1.60	.....	2.40	.....	.....

FALL CREEK STATION ON SAN MIGUEL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 264, is located about 300 yards southwest of Fall Creek, Colorado, a station on the Rio Grande Southern Railroad. Discharge measurements are made from the wagon bridge. The gage is vertical, 4 inches square, and is spiked to the west side of the north abutment. One bench mark is a bolthead in the north end of the west truss, 1 foot from the gage. It is 11.15 feet above the gage zero. The second bench mark is a spike driven into a tree 200 feet northwest. This is 8.65 feet above the zero. As the channel at this point is nearly straight and the banks rarely overflow, the section is a desirable one for measurements. Fall Creek empties into the San Miguel about 200 feet below the gage. The observer is Mrs. H. H. Hart; post-office address, Sawpit, Colorado. The following is a list of discharge measurements made in 1897 by F. Cogswell:

April 20, gage height, 3.40 feet; discharge, 304 second-feet.
May 11, gage height, 4.05 feet; discharge, 572 second-feet.
June 22, gage height, 4.45 feet; discharge, 811 second-feet.
July 20, gage height, 3.45 feet; discharge, 336 second-feet.
August 24, gage height, 2.85 feet; discharge, 145 second-feet.
September 21, gage height, 3.30 feet; discharge, 248 second-feet.
October 19, gage height, 3.05 feet; discharge, 197 second-feet.

Daily gage height, in feet, of San Miguel River at Fall Creek, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.45	3.70	4.60	4.05	3.30	2.80	3.35	2.80
2	2.35	3.75	4.50	4.05	3.40	2.85	3.25	2.80
3	2.35	3.75	4.10	4.15	3.40	3.15	3.15	2.75
4	2.25	3.65	3.95	3.90	3.35	3.00	3.10	2.75
5	2.55	3.75	4.10	3.70	3.25	2.95	3.05	2.75
6	2.55	3.85	4.10	3.60	3.20	2.90	3.00	2.70
7	2.55	3.95	4.30	3.65	3.20	2.90	3.20	2.65
8	2.60	4.10	4.45	3.90	3.20	3.15	3.10	2.50
9	2.65	4.00	4.65	3.85	3.15	3.10	3.15	2.50
10	2.80	4.10	4.65	3.80	3.10	3.00	3.15	2.55
11	2.75	4.00	4.40	3.85	3.10	3.00	3.10	2.65
12	2.70	4.00	4.45	3.80	3.00	3.00	3.10	2.70
13	2.80	4.10	4.50	3.80	3.00	3.05	3.10	2.70
14	2.90	4.15	4.55	3.80	3.00	3.45	3.05	2.75
15	3.05	4.10	4.65	3.75	3.05	3.35	3.05	2.75
16	3.25	4.15	4.70	3.70	3.05	3.30	3.15	2.60
17	3.35	4.05	4.40	3.65	3.00	3.20	3.15	2.55
18	3.60	4.20	4.40	3.60	3.00	3.15	3.00	2.60
19	3.55	4.20	4.40	3.55	3.00	3.10	3.05	2.55
20	3.55	4.05	4.25	3.50	2.90	3.20	3.00	2.60
21	3.50	4.05	4.45	3.25	2.85	3.30	3.00	2.55
22	3.25	4.05	4.50	3.25	2.80	3.35	2.95	2.50
23	3.25	4.25	4.50	3.30	2.75	3.20	2.85	2.50
24	3.35	4.40	4.45	3.45	2.75	3.20	2.80	2.50
25	3.55	4.50	4.45	3.45	2.80	3.25	2.95	2.50
26	3.70	4.65	4.50	3.45	2.80	3.25	2.85	2.40
27	3.80	4.65	4.20	3.40	2.80	3.20	2.85	2.40
28	3.65	4.40	3.95	3.30	2.80	3.25	2.75	2.45
29	3.60	4.60	4.00	3.30	2.80	3.30	2.75	2.40
30	3.55	4.55	4.05	3.30	2.80	3.30	2.80	2.35
31	.....	4.50	.....	3.35	2.75	.....	2.85	.....

DOLORES STATION ON DOLORES RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 261, is located about one-half mile above the railroad depot at Dolores, Colorado. The gage consists of a vertical 2 by 6 inch plank, bolted to the abutment of a footbridge, on the left side of the river. The bench mark consists of a nail driven in the base of a cottonwood tree 18 feet southwesterly from the gage, and it is 15.60 feet above datum. The observer is Mrs. Mary D. Smith. The following discharge measurements were made in 1897 by F. Cogswell:

April 21, gage height, 5.10 feet; discharge, 2,133 second-feet.
May 12, gage height, 5.15 feet; discharge, 2,216 second-feet.
June 23, gage height, 4.20 feet; discharge, 1,089 second-feet.
July 21, gage height, 3.00 feet; discharge, 273 second-feet.
August 25, gage height, 2.65 feet; discharge, 92 second-feet.
September 22, gage height, 3.32 feet; discharge, 404 second-feet.
October 20, gage height, 3.25 feet; discharge, 330 second-feet.

Daily gage height, in feet, of Dolores River at Dolores, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.00	5.15	5.55	3.60	2.90	2.60	3.25	3.00
2	3.00	5.40	5.40	3.55	2.90	2.60	3.50	3.00
3	3.05	5.45	4.85	3.55	3.00	2.85	3.50	3.00
4	3.25	5.35	4.75	3.55	3.00	2.80	3.55	3.00
5	3.35	5.45	4.80	3.40	3.00	3.80	3.40	3.00
6	3.35	5.45	4.75	3.40	2.95	3.80	3.30	2.90
7	3.35	5.50	4.85	3.40	2.90	3.80	3.30	2.90
8	3.35	5.60	4.95	3.40	2.90	3.90	3.45	2.85
9	3.50	5.85	4.80	3.50	2.90	3.25	3.55	2.85
10	3.75	5.60	5.15	3.40	2.90	3.15	3.45	3.05
11	4.10	5.40	4.85	3.30	2.85	3.05	3.40	2.95
12	4.15	5.20	5.35	3.30	2.80	3.20	3.30	2.95
13	4.45	5.45	4.65	3.30	2.80	3.20	3.30	2.90
14	4.70	5.50	4.80	3.20	2.80	3.35	3.30	2.90
15	5.05	5.45	4.80	3.20	2.80	3.25	3.30	2.85
16	5.15	5.20	4.75	3.30	2.80	3.15	3.30	2.80
17	5.40	5.10	4.50	3.30	2.80	3.10	3.30	2.80
18	5.95	5.35	4.40	3.20	2.80	3.00	3.30	2.80
19	5.85	5.55	4.25	3.15	2.70	2.95	3.30	2.80
20	5.40	5.75	4.25	3.00	2.70	3.10	3.20	2.80
21	5.15	5.65	4.25	3.00	2.70	3.40	3.20	2.80
22	4.85	5.40	4.25	3.00	2.70	3.40	3.20	2.80
23	4.75	5.40	4.20	3.20	2.70	3.20	3.20	2.80
24	4.70	5.70	4.05	3.10	2.70	3.25	3.20	2.80
25	5.15	5.80	3.95	3.10	2.70	3.40	3.20	2.80
26	5.50	5.65	3.95	3.05	2.70	3.45	3.10	2.80
27	5.80	5.75	3.80	3.00	2.70	3.45	3.10	2.80
28	5.05	5.05	3.70	3.00	2.70	3.35	3.10	2.70
29	5.20	5.35	3.65	2.95	2.70	3.45	3.00	2.70
30	5.15	5.60	3.55	2.95	2.70	3.40	3.00	2.70
31	.....	5.45	.....	2.90	2.60	.....	3.00	.....

ARBOLES STATION ON SAN JUAN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 279, is located at a foot bridge about 1,000 feet below the Denver and Rio Grande Railroad depot at Arboles, Colorado, and is above the mouth of the Piedra River. The gage consists of two inclined 4 by 4 inch timbers marked to vertical tenths of a foot, the space between marks being 0.131 of a foot, and it is bolted to the rocky bank on the right-hand side of the river. The left bank is low and liable to overflow, the right is high and rocky; the current is sluggish, and the bed sandy and shifting. Discharge measurements are made during high water at the footbridge, and at low stages about 1,300 feet below the gage, where the bed of the stream is composed of small stones and is less liable to change, and the current is swift. The observer is T. F. Burke, section foreman. The following discharge measurements have been made in 1897 by F. Cogswell:

April 25, gage height, 8.30 feet; discharge, 2,753 second-feet.
May 16, gage height, 8.80 feet; discharge, 3,316 second feet.
June 27, gage height, 7.60 feet; discharge, 1,604 second-feet.
July 25, gage height, 6.50 feet; discharge, 446 second-feet.
August 29, gage height, 5.80 feet; discharge, 209 second-feet.
September 26, gage height, 8.00 feet; discharge 2,048 second-feet.
October 24, gage height, 6.90 feet; discharge, 795 second-feet.

Daily gage height, in feet, of San Juan River at Arboles, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	6.50	8.20	9.10	7.25	6.20	5.70	6.50	6.60
2	6.80	8.40	8.85	7.30	6.20	5.70	6.50	6.50
3	6.60	8.45	8.35	7.45	6.30	6.50	6.65	6.50
4	6.75	8.60	8.10	7.40	6.30	5.90	7.50	6.50
5	6.95	9.05	8.05	7.10	6.35	6.00	7.35	6.50
6	7.45	8.50	8.10	7.05	6.25	6.65	7.10	6.50
7	7.85	8.63	8.25	6.90	6.20	7.00	7.05	6.50
8	7.25	8.70	8.50	6.95	6.20	6.40	7.15	6.40
9	7.20	8.85	8.50	7.05	6.20	6.80	8.05	6.40
10	7.25	8.90	8.60	7.10	6.30	6.50	7.90	6.40
11	7.85	8.55	8.75	7.05	6.20	6.45	7.70	6.40
12	7.65	8.50	8.50	6.90	6.10	7.90	7.55	6.40
13	7.75	8.70	8.40	6.90	6.10	6.95	7.40	6.40
14	7.80	8.75	8.40	6.70	6.15	7.15	7.20	6.35
15	8.10	8.60	8.35	6.70	6.10	6.65	7.50	6.30
16	8.20	8.75	8.40	6.70	6.15	6.50	7.50	6.30
17	8.60	8.65	8.15	6.70	6.35	6.40	7.50	6.30
18	8.90	8.85	7.85	6.75	6.15	6.40	7.40	6.30
19	8.90	9.20	7.80	6.60	6.10	6.30	7.35	6.20
20	8.50	9.55	7.90	6.60	6.05	6.30	7.20	6.20
21	8.45	9.05	7.85	6.50	6.00	6.60	7.05	6.20
22	8.10	8.75	7.95	6.50	6.00	6.45	6.95	6.20
23	7.70	8.95	7.95	6.75	6.00	6.40	6.90	6.20
24	7.85	9.20	7.75	6.65	6.00	6.40	6.90	6.20
25	8.15	9.20	7.60	6.50	5.90	7.10	6.85	6.20
26	8.35	9.30	7.70	6.40	5.90	7.65	6.80	6.20
27	8.75	9.35	7.65	6.40	5.90	7.05	6.80	6.20
28	8.20	9.05	7.55	6.30	5.90	6.90	6.70	6.15
29	8.10	9.10	7.40	6.30	5.80	6.70	6.70	6.10
30	8.10	9.00	7.20	6.25	5.80	6.55	6.60	6.10
31	.....	9.05	.....	6.20	5.70	.....	6.60	.....

ARBOLES STATION ON PIEDRA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 281, is located at the railroad bridge across the Piedra River, about one-half mile from the Denver and Rio Grande Railroad depot at Arboles, Colorado. The Piedra empties into the San Juan a short distance below this point. The gage is bolted to the stone abutment of the railroad bridge on the right-hand side of the stream, and consists of a vertical 4 by 4 inch timber. A cross cut in the top of the abutment in the southeast corner of bridge 402A is 14.88 feet above gage zero. The banks are both high, the current is swift, the bed is composed of small stones, and the cross section does not change materially. The observer is T. F. Burke. The following discharge measurements were made in 1897 by F. Cogswell:

April 24, gage height, 5.20 feet; discharge, 1,429 second-feet.
May 15, gage height, 5.65 feet; discharge, 1,629 second-feet.
June 26, gage height, 4.20 feet; discharge, 677 second-feet.
July 24, gage height, 3.10 feet; discharge, 230 second-feet.
August 28, gage height, 2.60 feet; discharge, 65 second-feet.
September 25, gage height, 4.15 feet; discharge, 675 second-feet.
October 23, gage height, 4.00 feet; discharge, 586 second-feet.

Daily gage height, in feet, of Piedra River at Arboles, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.45	5.80	6.15	3.70	2.80	2.60	3.70	3.50
2	3.75	6.10	5.85	3.75	2.80	2.60	4.20	3.40
3	3.55	6.05	5.35	4.00	2.80	3.20	4.25	3.40
4	3.65	6.40	5.10	3.90	2.80	3.00	5.00	3.35
5	4.20	6.45	5.05	3.70	2.80	2.95	5.05	3.30
6	4.45	6.60	5.05	3.60	2.80	3.40	4.75	3.30
7	4.95	6.65	5.25	3.50	2.80	3.50	4.55	3.30
8	4.80	6.60	5.40	3.50	2.80	3.30	4.60	3.30
9	4.80	6.25	5.35	3.45	2.80	3.65	5.75	3.20
10	4.90	6.25	5.45	3.60	2.95	3.40	5.25	3.25
11	5.45	5.90	5.35	3.50	2.80	3.35	4.95	3.30
12	5.45	5.75	5.30	3.50	2.75	4.20	4.85	3.20
13	5.55	5.95	5.15	3.40	2.85	4.00	4.65	3.20
14	5.65	5.95	5.20	3.30	2.80	4.05	4.50	3.20
15	6.00	5.75	5.15	3.25	2.75	3.65	4.90	3.10
16	6.00	5.80	5.30	3.30	2.70	3.50	4.85	3.10
17	6.20	5.65	5.00	3.25	2.70	3.45	4.60	3.10
18	6.35	5.95	4.70	3.20	2.80	3.30	4.50	3.05
19	6.35	6.10	4.65	3.20	2.70	3.30	4.40	3.00
20	6.00	6.15	4.70	3.10	2.80	3.30	4.25	3.00
21	6.05	5.95	4.60	3.00	2.75	4.05	4.10	3.00
22	5.70	5.80	4.60	3.00	2.70	3.70	4.05	3.00
23	5.50	5.90	4.55	3.05	2.70	3.55	4.00	3.00
24	5.30	6.35	4.45	3.10	2.70	3.60	3.90	3.00
25	5.50	6.40	4.25	3.00	2.60	4.00	3.80	3.00
26	5.60	6.40	4.25	3.00	2.60	4.35	3.80	3.00
27	6.00	6.35	4.20	3.00	2.60	4.05	3.70	3.00
28	5.65	6.05	4.05	2.90	2.60	3.95	3.70	.....
29	5.70	6.15	3.90	2.90	2.60	3.80	3.65	.....
30	5.80	6.00	3.80	2.90	2.60	3.70	3.60	.....
31	.....	6.05	.....	2.90	2.60	.....	3.50	.....

DURANGO STATION ON ANIMAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 283, is located about 200 yards west of the railroad station at Durango, Colorado, at the wagon bridge crossing Animas River, 200 feet above the Rio Grande Southern Railroad Bridge. The observer is George Robertson, a miller at Durango. The gage is spiked to the west side of the south end of the middle pier of the wagon bridge. The head of a bolt at the east abutment of the railroad bridge is 17.24 feet above gage datum. The banks are high and rocky and the section is excellent for obtaining accurate measurements of discharge. Lightner Creek enters Animas River from the right about 100 feet below the wagon bridge and between it and the railroad bridge. The following discharge measurements were made in 1897 by F. Cogswell:

April 23, gage height, 7.75 feet; discharge, 2,176 second-feet.
May 14, gage height, 9.20 feet; discharge, 4,786 second-feet.
June 25, gage height, 7 85 feet; discharge, 2,534 second-feet.
July 23, gage height, 6.10 feet; discharge, 997 second-feet.
August 27, gage height, 5.10 feet; discharge, 328 second-feet.
September 24, gage height, 6.05 feet; discharge, 905 second-feet.
October 22, gage height, 6.50 feet; discharge, 1,121 second-feet.

Daily gage height, in feet, of Animas River at Durango, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.10	.....	.....	5.75	8.75	9.40	7.15	5.70	5.10	6.35	5.80	5.20
2	5.20	.....	.....	5.80	8.85	8.85	7.00	5.75	5.00	6.75	5.80	5.20
3	.....	5.00	5.10	5.75	8.70	8.15	7.00	5.75	5.60	7.05	5.80	5.20
4	.....	.....	.....	6.20	8.55	7.90	6.80	5.75	5.70	7.15	5.70	5.15
5	5.20	.....	.....	6.20	8.50	8.10	6.50	5.90	5.65	7.05	5.70	.....
6	.....	4.90	5.00	7.10	8.80	8.25	6.55	5.80	5.60	6.85	5.70	5.30
7	.....	.....	.....	7.30	9.20	8.40	6.85	5.80	5.60	6.70	5.70	.....
8	.....	.....	.....	7.40	9.50	8.90	6.85	5.70	5.70	6.80	5.60	.....
9	5.00	5.00	.....	7.40	9.45	8.95	7.00	5.70	6.25	7.65	5.60	.....
10	.....	.....	5.10	7.75	9.30	9.10	6.95	5.65	5.95	7.45	5.60	.....
11	.....	.....	.....	7.80	8.90	8.60	6.85	5.60	5.95	7.25	5.60	5.10
12	5.00	.....	.....	7.55	8.70	8.50	6.75	5.60	6.55	7.15	5.60	.....
13	.....	5.10	5.00	7.75	8.95	8.55	6.55	5 60	6.55	7.05	5.50	.....
14	.....	.....	.....	8.00	9.20	8.90	6.45	5.55	6.70	6.95	5.50	5.30
15	.....	.....	.....	8.60	8.95	8.95	6.45	5.50	6.50	7.55	5.50	.....
16	4.90	5.00	.....	8.80	8.95	9.05	6.45	5.50	6.20	7.25	5.50	.....
17	.....	.....	5.10	8.95	8.60	8.45	6.35	5.50	6.00	7.05	5.50	.....
18	.....	.....	.....	9.00	9.05	8.05	6.25	5.50	5.95	6.85	5.40	5.20
19	.....	.....	.....	9.20	9.15	7.95	6.15	5.45	5.85	6.75	5.40	.....
20	5.00	4 80	5.20	8.50	9.00	8.10	6.05	5.40	5.80	6.65	5.40	.....
21	.....	.....	.....	8.30	8.70	8.30	6.00	5.40	6.30	6.55	5.40	5.30
22	.....	.....	.....	7.90	8.70	8.30	6.00	5.35	6.25	6.50	5.40	.....
23	5.30	.....	.....	7.65	9.25	8.40	6.05	5.30	6.15	6.40	5.45	.....
24	.....	5.00	5.10	7.50	9.60	8.10	6.05	5.25	6.05	6.30	5.40	5.10
25	.....	.....	.....	8.35	9.75	7.75	6.00	5.20	6.25	6.30	5.40	.....
26	.....	.....	.....	8.65	9.65	8 00	5.90	5.20	6.50	6.20	5.40	.....
27	5.00	5.10	5.50	8.90	9.55	8 05	5.90	5.10	6.40	6.10	5.35	.....
28	.....	.....	.....	8.35	8.85	7.50	5.80	5.10	6.25	6.00	5.30	5.20
29	.....	.....	.....	8.50	9.25	7.30	5.80	5.10	6.30	6.00	5.25	.....
30	5.00	.....	5.60	8.60	9.35	7.15	5 75	5.10	6.30	5.95	5.20	.....
31	.....	.....	.....	.....	9.25	.....	5.70	5.10	.....	5.90	.....	5.50

BUTTES STATION ON GILA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 286, is located at the buttes 16 miles above Florence, Arizona. This gage is bolted to a solid rock on the right bank, where the river emerges from the lower end of the gorge. Measurements are made from a car suspended from a cable, a short distance above the gage. Owing to the shifting character of the bottom, it was necessary to make a large number of discharge measurements and the following were made by W. J. Brash and A. T. Colton in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Jan. 1....	2.30	445	Feb. 26....	2.60	646	May 28...	1.65	94
Jan. 5....	2.25	413	Mar. 2.....	2.50	593	June 10..	1.50	72
Jan. 8....	2.24	377	Mar. 5.....	2.52	614	June 30..	1.30	20
Jan. 12...	2.90	853	Mar. 9.....	2.60	687	July 11...	3.00	726
Jan. 14...	3.10	846	Mar. 12....	2.48	568	July 27...	1.93	173
Jan. 15...	3.80	1,891	Mar. 16....	2.45	585	Aug. 11...	2.25	365
Jan. 16...	5.30	3,895	Mar. 20....	2.58	681	Aug. 14...	4.70	3,181
Jan. 18...	4.60	3,085	Mar. 23....	2.90	1,010	Aug. 31...	1.90	246
Jan. 22...	3.40	1,446	Mar. 26....	2.74	833	Sept. 8...	6.75	5,588
Jan. 26...	3.05	1,045	Mar. 31....	2.78	837	Sept. 13..	3.50	1,946
Jan. 29...	2.85	912	Apr. 8.....	2.54	675	Sept. 15..	5.30	4,950
Feb. 1....	3.50	1,530	Apr. 14....	2.70	797	Sept. 23..	3.75	2,099
Feb. 5....	3.20	1,123	Apr. 20....	2.60	757	Sept. 28..	3.70	2,068
Feb. 10...	2.85	926	Apr. 28....	2.43	516	Oct. 10...	2.65	868
Feb. 13...	2.71	840	May 6.....	2.22	318	Oct. 24...	2.23	601
Feb. 16...	2.54	700	May 14....	1.96	188			
Feb. 22...	2.82	808	May 20....	1.80	134			

Daily gage height, in feet, of Gila River at the Buttes, Arizona, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.30	3.50	2.57	2.75	.....	1.60	1.30	2.40	1.80	3.10
2	2.30	3.40	2.50	2.70	2.30	1.50	1.30	2.40	1.80	2.97
3	2.26	3.30	2.52	2.68	.....	1.50	1.30	2.20	1.80	2.90
4	2.26	3.25	2.64	2.65	2.27	1.50	1.30	2.30	1.76	2.80
5	2.25	3.20	2.52	.....	.....	1.50	1.30	2.60	1.72	2.65
6	2.25	3.10	2.52	2.67	2.22	1.50	1.30	2.40	1.73	2.60
7	2.24	3.00	2.70	.....	.....	1.50	1.30	2.30	1.83	2.58
8	2.24	2.95	2.62	2.54	2.17	1.50	1.20	3.00	7.00	2.55
9	2.24	2.90	2.60	.....	.....	1.50	1.20	2.30	4.40	2.47
10	2.23	2.85	2.60	2.60	2.10	1.50	4.10	2.20	3.80	.....
11	3.28	2.80	2.50	.....	.....	1.50	3.00	2.20	4.90	.....
12	2.90	2.73	2.48	2.67	2.05	1.55	4.00	2.20	4.20	.....
13	3.87	2.71	2.48	.....	.....	1.50	3.40	5.30	3.50	.....
14	3.10	2.70	2.50	2.70	1.96	1.50	3.00	4.70	4.90	.....
15	3.45	2.62	2.40	.....	.....	1.50	2.50	4.70	5.30	.....
16	5.30	2.54	2.45	2.70	1.91	1.50	2.00	4.80	5.10	.....
17	5.60	2.50	2.46	.....	.....	1.50	2.20	2.90	4.60	.....
18	4.60	2.47	2.50	2.70	1.88	1.50	2.10	2.70	5.40	.....
19	4.10	2.45	2.53	.....	.....	1.50	3.00	2.40	4.80	.....
20	3.90	2.50	2.58	2.65	1.80	1.40	3.50	2.30	3.85	.....
21	3.70	2.95	2.71	.....	.....	1.40	2.50	2.30	4.60	.....
22	3.40	2.85	2.83	2.59	1.77	1.40	3.00	2.60	4.20	.....
23	3.30	2.80	2.90	.....	.....	1.40	3.00	2.40	3.75	.....
24	3.25	2.79	2.90	2.55	1.70	1.40	2.50	2.20	3.70	.....
25	3.15	2.65	2.90	.....	.....	1.40	2.00	2.20	3.65	.....
26	3.05	2.60	2.74	2.50	1.68	1.30	2.20	2.10	3.75	.....
27	3.00	2.58	2.72	.....	.....	1.30	2.10	2.10	3.70	.....
28	2.90	2.58	2.70	2.43	1.65	1.30	2.50	2.00	3.70	.....
29	2.85	.....	2.73	.....	.....	1.30	2.00	2.00	3.55	.....
30	3.25	.....	2.85	2.40	.....	1.30	2.00	1.90	3.25	.....
31	3.17	.....	2.78	.....	.....	.....	2.00	1.90	.....	.....

McDOWELL STATION ON SALT RIVER.

This station is located ¾ mile above the mouth of the Verde River and 35 miles northeast of Phœnix, Arizona, and was established April 20, 1897. The gage consists of 2 by 6 inch scantling, bolted to rocks on south side of river about 300 feet above the cable. The bench mark is a nail in polyverde tree about 75 feet west of north cable anchorage, and it is 17.33 feet above gage zero. The observer is B. Valasco. The following is a list of discharge measurements made in 1897 by W. A. Farish and others:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 21	13.30	4,085	May 29	10.40	715	June 30	9.55	217
Apr. 25	12.50	2,913	June 1	10.35	647	July 10	9.50	169
Apr. 28	12.10	2,290	June 3	10.30	606	July 19	9.55	198
Apr. 30	12.00	2,035	June 5	10.23	569	Aug. 15	10.10	373
May 4	11.55	1,639	June 8	10.09	476	Aug. 29	10.15	403
May 8	11.33	1,563	June 10	10.00	456	Sept. 13	11.35	733
May 11	11.20	1,385	June 12	9.95	430	Sept. 26	11.45	1,068
May 15	10.94	1,223	June 15	9.90	399	Oct. 20	10.10	393
May 18	10.73	992	June 17	9.86	379	Oct. 31	10.10	325
May 20	10.66	875	June 19	9.80	341	Nov. 21	10.00	284
May 22	10.61	852	June 22	9.74	299	Nov. 28	10.00	270
May 25	10.54	805	June 24	9.70	270	Dec. 19	10.10	264
May 27	10.45	748	June 26	9.63	244	Dec. 27	10.05	273

Daily gage height, in feet, of Salt River at McDowell, Arizona, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	11.00	10.35	9.50	9.50	10.00	11.45	10.05	10.00
2	.....	11.75	10.32	9.72	9.55	9.88	11.30	10.05	10.05
3	.....	11.62	10.29	9.52	10.55	10.40	10.90	10.05	10.10
4	.....	11.55	10.26	9.50	9.90	10.45	11.40	10.05	10.10
5	.....	11.62	10.23	9.36	10.04	10.00	10.65	10.05	10.10
6	.....	11.62	10.18	9.64	9.70	10.44	10.60	10.05	10.10
7	.....	11.48	10.12	9.66	9.88	10.60	10.70	10.05	10.10
8	.....	11.44	10.08	9.36	9.75	10.90	10.40	10.00	10.10
9	.....	11.40	10.04	9.34	9.70	10.90	10.90	10.00	10.10
10	.....	11.26	9.99	9.50	9.70	11.51	10.05	10.00	10.10
11	.....	11.20	9.96	9.50	9.82	12.73	10.04	10.00	10.10
12	.....	11.12	9.95	9.50	10.85	11.15	10.20	10.00	10.10
13	.....	11.06	9.90	9.50	10.62	11.50	10.60	10.00	10.10
14	.....	11.00	9.87	9.60	10.85	11.50	10.30	10.00	10.10
15	.....	10.94	9.90	9.76	10.10	10.60	10.30	10.00	10.10
16	.....	10.85	9.86	9.60	10.10	10.20	10.20	10.00	10.10
17	.....	10.75	9.85	9.60	10.55	10.30	10.30	10.00	10.10
18	.....	10.72	9.83	9.58	10.90	10.30	10.20	10.05	10.10
19	.....	10.68	9.79	9.55	10.50	10.03	10.30	10.00	10.10
20	13.60	10.65	9.77	9.52	10.76	10.48	10.10	10.00	10.15
21	13.30	10.62	9.75	9.43	10.30	10.25	10.25	10.00	10.15
22	13.20	10.60	9.73	9.45	10.20	10.90	9.90	10.00	10.10
23	12.90	10.58	9.70	9.45	10.20	11.00	10.00	10.00	10.10
24	12.60	10.53	9.68	9.45	10.10	11.45	10.45	10.00	10.10
25	12.50	10.53	9.65	9.42	10.00	11.50	10.50	10.00	10.10
26	12.32	10.49	9.62	9.45	10.30	11.45	10.45	10.00	10.05
27	12.15	10.44	9.60	9.45	10.60	11.70	10.45	10.00	10.05
28	12.10	10.41	9.58	9.42	10.50	12.02	10.02	10.00	10.10
29	12.10	10.40	9.56	9.75	10.00	11.90	10.90	10.00	10.10
30	12.00	10.39	9.55	9.55	10.45	11.75	10.75	10.00	10.05
31	.....	10.36	.....	9.55	10.00	.....	10.10	.....	10.05

MCDOWELL STATION ON VERDE RIVER.

This station is located ¾ mile above the mouth of Verde River, and 35 miles northeast of Phœnix, Arizona, and was established April 20, 1897. The gage consists of a 2 by 4 inch inclined rod fastened to posts driven into the east bank of the river about 400 feet below the gaging cable. The bench mark is on a catclaw tree about 100 feet southeast from the old gage on cottonwood tree, which latter is 60 feet below the cable. The elevation of the bench mark is 27.02 feet above gage datum. The observer is B. Valasco. The following is a list of discharge measurements made by W. A. Farish and others in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 21	8.85	1,328	May 29	7.74	172	July 10	7.65	183
Apr. 25	8.50	731	June 1	7.80	177	July 19	7.70	186
Apr. 28	8.37	540	June 3	7.78	174	Aug. 15	7.95	322
Apr. 30	8.32	508	June 8	7.75	176	Aug. 29	8.51	440
May 4	8.16	364	June 10	7.76	178	Sept. 13	9.35	1,949
May 8	8.12	325	June 12	7.78	159	Sept. 26	7.60	435
May 11	8.00	259	June 15	7.70	165	Oct. 21	6.70	279
May 15	7.93	236	June 17	7.63	138	Oct. 31	6.65	305
May 18	7.94	229	June 19	7.63	132	Nov. 21	6.60	246
May 20	7.85	227	June 22	7.58	128	Nov. 28	6.63	264
May 22	7.88	224	June 24	7.63	135	Dec. 19	6.75	264
May 25	7.84	205	June 26	7.55	122	Dec. 26	6.70	308
May 27	7.85	244	June 30	7.56	111			

Daily gage height, in feet, of Verde River at McDowell, Arizona, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.30	7.80	7.56	7.55	7.70	7.45	6.65	6.65
2	.....	8.23	7.76	7.54	7.54	7.55	7.00	6.60	6.70
3	.....	8.18	7.77	7.43	7.52	7.60	7.00	6.65	6.70
4	.....	8.16	7.77	7.42	7.52	7.85	7.40	6.65	6.70
5	.....	8.14	7.78	7.38	7.56	7.60	7.30	6.65	6.65
6	.....	8.12	7.76	7.44	7.60	7.50	7.10	6.60	6.60
7	.....	8.12	7.74	7.44	7.60	7.61	7.10	6.60	6.60
8	.....	8.12	7.75	7.40	7.65	8.80	7.20	6.60	6.60
9	.....	8.08	7.74	7.40	7.64	8.90	6.90	6.60	5.65
10	.....	8.05	7.76	7.68	7.72	8.30	7.10	6.60	6.65
11	.....	8.00	7.76	7.65	7.72	12.00	7.00	6.60	6.65
12	.....	8.00	7.78	7.88	9.00	12.00	7.10	6.65	6.65
13	.....	7.98	7.76	7.80	8.50	9.40	7.00	6.60	6.65
14	.....	7.93	7.74	7.72	8.00	9.40	7.00	6.65	6.60
15	.....	7.93	7.70	7.74	8.00	7.50	7.00	6.95	6.60
16	.....	7.93	7.66	7.70	8.00	7.50	7.00	6.60	6.60
17	.....	7.92	7.62	7.75	8.20	7.85	7.10	6.65	6.65
18	.....	7.92	7.62	7.75	8.50	7.60	7.10	6.65	6.65
19	.....	7.91	7.62	7.70	8.10	7.10	7.10	6.60	6.75
20	9.00	7.86	7.62	7.64	8.50	7.20	7.10	6.60	6.75
21	8.80	7.84	7.59	7.43	8.60	2.10	6.70	6.60	6.80
22	8.70	7.86	7.58	7.58	8.70	7.00	6.70	6.60	6.75
23	8.65	7.84	7.60	7.64	7.90	7.50	6.65	6.60	9.70
24	8.60	7.84	7.62	7.58	8.30	7.45	6.65	6.60	6.70
25	8.50	7.84	7.60	7.54	8.30	7.65	6.60	6.60	6.70
26	8.42	7.84	7.54	7.52	8.45	7.60	6.65	6.60	6.70
27	8.38	7.84	7.56	7.50	8.45	9.00	6.70	6.60	1.70
28	8.37	7.82	7.57	7.49	8.45	9.90	6.70	6.60	6.70
29	8.36	7.74	7.57	7.60	8.50	7.80	6.65	6.60	6.70
30	8.32	7.85	7.56	7.50	7.50	7.55	6.65	6.60	6.70
31	.....	7.84	.....	7.51	7.50	.....	6.65	.....	6.70

YUMA STATION ON COLORADO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 298, is located at the bridge of the Southern Pacific Railroad Company at Yuma, Arizona, and the gage readings are maintained by that company. The gage at this point, reading from 10 to 22 feet, is nailed to the lower side of the first pier on the south bank of the river; the portion reading from 22 feet to 40 feet is nailed to a large post on the north side, east of the bridge. The figures of gage height, plus 100, indicate the elevation above sea level according to the South Pacific elevation. The channel of the river is shifting, scouring or filling with every change of river height. No discharge measurements were made in 1897.

Daily gage height, in feet, of Colorado River at Yuma, Arizona, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	18.58	18.33	18.33	19.42	22.42	25.17	21.50	19.25	18.58	18.92	18.75	18.42
2....	18.75	18.17	18.50	19.67	22.42	25.42	21.25	19.17	18.58	18.92	18.83	18.42
3....	18.58	18.33	18.50	19.25	22.67	25.67	20.92	19.17	18.50	18.92	19.17	18.75
4....	18.50	18.25	19.17	20.17	22.92	25.75	20.92	19.17	18.50	18.83	19.17	18.58
5....	18.42	18.42	19.33	20.00	23.00	25.83	20.92	19.00	18.58	19.17	18.92	18.42
6....	18.33	18.50	19.08	20.42	22.92	25.83	20.92	18.92	18.50	19.17	18.75	18.58
7....	18.25	18.50	19.75	20.42	23.00	25.92	20.58	18.83	18.42	18.92	18.75	18.58
8....	18.17	18.50	19.42	20.67	23.42	26.00	20.42	18.83	18.25	18.75	18.75	18.42
9....	18.00	18.42	19.00	21.00	23.75	26.08	20.42	18.67	18.25	18.42	18.67	18.42
10....	18.00	18.17	19.50	21.42	24.00	26.00	20.25	18.75	18.17	18.50	18.67	18.33
11....	18.00	18.00	20.33	21.42	24.33	25.83	20.83	18.75	18.08	18.83	18.67	18.25
12....	17.92	17.92	19.75	21.00	24.58	25.33	20.50	18.58	18.42	19.25	18.58	18.25
13....	18.33	18.17	19.58	21.42	24.83	24.75	20.58	18.83	18.17	21.00	18.58	18.08
14....	19.00	18.25	19.33	21.50	24.92	24.00	20.25	18.75	18.67	20.75	18.50	18.08
15....	20.92	18.25	19.17	21.50	25.08	23.58	20.08	19.00	18.75	21.50	18.58	18.08
16....	21.42	18.25	19.00	21.42	25.25	23.33	20.25	18.92	18.33	21.42	18.58	18.00
17....	22.50	18.25	19.17	21.25	25.33	23.25	20.25	18.92	18.25	20.92	18.58	18.00
18....	22.83	18.17	19.50	21.25	25.42	23.17	20.33	19.00	19.33	20.17	18.58	18.00
19....	21.92	18.17	19.25	21.42	25.50	23.08	20.33	19.08	19.83	19.92	18.58	18.00
20....	20.00	18.17	19.17	21.42	25.50	23.25	20.25	19.17	20.25	19.67	18.50	18.00
21....	19.42	18.17	19.00	21.42	25.42	23.25	20.00	19.08	20.75	19.58	18.42	17.92
22....	19.75	18.17	18.92	21.92	25.25	23.42	19.75	19.08	20.75	19.42	18.42	18.00
23....	19.42	18.17	18.92	22.42	25.08	23.25	19.50	18.92	19.83	19.92	18.42	18.17
24....	19.00	18.00	18.92	22.75	25.00	22.75	19.50	18.83	19.50	19.50	18.33	18.25
25....	18.83	18.00	18.75	23.00	25.00	22.33	19.42	18.75	19.50	19.33	18.33	18.08
26....	18.75	18.42	19.33	23.17	25.17	22.17	19.42	19.25	19.25	19.25	18.42	18.08
27....	18.67	18.42	19.17	23.00	25.25	21.75	19.42	18.75	19.00	19.00	18.50	18.08
28....	18.67	18.33	19.17	22.83	25.42	21.67	19.33	18.67	18.83	19.00	18.50	18.08
29....	18.67	.....	18.92	22.50	25.42	21.67	19.33	18.75	19.08	19.00	18.50	18.08
30....	18.50	.....	18.92	22.42	25.33	21.67	19.33	18.75	18.92	18.83	18.42	18.08
31....	18.42	.....	19.33	.....	25.25	.....	19.25	18.75	.....	18.75	.....	18.00

ELKO STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 299, is located at a point 1 mile southwest of the town of Elko, Nevada. The gage is inclined, fastened to iron bolts driven into the solid rock, and placed on the left bank immediately below the bridge. The bench mark is on the southwest corner of the cofferdam surrounding a stone pier of the bridge, 80 feet north of the gage, and is at an elevation of 7.5 feet above zero on the gage. The channel is straight both above and below this point; the right bank is quite low, but the left is high and rocky. The bed of the stream is of gravel and sand, shifting slightly. The observer is John Garrecht. The following discharge measurements were made in 1897 by L. H. Taylor:

March 23, gage height, 2.80 feet; discharge, 140 second-feet.
April 9, gage height, 6.20 feet; discharge, 1,276 second-feet.
May 6, gage height, 7.20 feet; discharge, 1,778 second-feet.
June 22, gage height, 4.93 feet; discharge, 773 second-feet.
July 10, gage height, 3.30 feet; discharge, 256 second-feet.
July 26, gage height, 2.45 feet; discharge, 88 second-feet.
September 6, gage height, 1.80 feet; discharge, 6 second-feet.
November 30, gage height, 2.20 feet; discharge, 44 second-feet.

Daily gage height, in feet, of Humboldt River at Elko, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.45	2.65	5.90	6.80	7.60	4.15	2.20	1.85	1.75	2.10	2.35
2	2.55	2.45	2.80	4.80	6.80	7.45	4.15	2.15	1.85	1.75	2.10	2.35
3	2.45	2.45	2.80	4.30	6.90	7.30	4.00	2.15	1.85	1.75	2.15	2.40
4	2.50	2.50	2.85	4.40	7.50	7.20	3.95	2.10	1.85	1.75	2.15	2.45
5	2.50	2.65	2.80	4.50	7.90	7.15	3.90	2.10	1.85	1.80	2.15	2.50
6	2.50	2.70	2.80	4.60	7.90	6.80	3.80	2.00	1.80	1.80	2.20	2.45
7	2.50	2.72	2.80	5.00	7.90	6.50	3.70	2.00	1.80	1.85	2.20	2.50
8	2.55	2.90	2.70	5.50	7.70	6.40	3.60	2.05	1.80	1.90	2.25	2.50
9	2.50	2.93	2.70	6.30	7.55	6.15	3.40	2.00	1.80	1.90	2.25	2.60
10	2.50	2.95	2.80	6.40	7.50	5.95	3.35	2.00	1.80	2.00	2.25	2.80
11	2.40	3.00	2.85	6.60	7.50	5.85	3.25	2.00	1.83	1.95	2.25	2.80
12	2.50	2.95	2.80	6.80	7.55	5.80	3.15	2.00	1.80	1.95	2.25	2.70
13	2.40	2.85	2.70	7.20	7.50	5.75	3.00	1.95	1.80	1.95	2.20	2.50
14	2.40	2.70	2.70	7.40	7.10	5.60	2.95	1.95	1.80	2.00	2.25	2.30
15	2.30	2.70	2.70	7.40	7.20	5.40	2.93	1.95	1.80	2.00	2.25	2.20
16	2.40	2.65	2.75	7.20	6.90	5.40	2.90	1.95	1.80	2.00	2.30	2.40
17	2.40	2.70	2.85	7.30	6.80	5.43	2.90	1.95	1.80	2.00	2.30	2.60
18	2.30	2.45	2.95	7.30	6.80	5.55	2.80	1.90	1.80	2.00	2.30	2.60
19	2.40	2.60	3.00	7.40	7.00	5.70	2.80	1.85	1.80	2.00	2.30	2.60
20	2.40	2.70	3.00	7.90	7.30	5.60	2.70	1.85	1.80	2.05	2.30	2.60
21	2.37	2.70	3.00	8.10	7.35	5.30	2.70	1.85	1.80	2.05	2.30	2.60
22	2.35	2.60	2.80	8.20	7.55	5.00	2.65	1.85	1.80	2.10	2.30	2.50
23	2.30	2.50	2.90	8.20	7.70	4.85	2.60	1.87	1.80	2.05	2.35	2.60
24	2.37	2.50	3.00	7.80	8.00	4.50	2.60	1.87	1.80	2.05	2.40	2.65
25	2.40	2.40	3.60	7.50	8.25	4.50	2.55	1.87	1.80	2.05	2.35	2.50
26	2.40	2.50	3.90	7.20	8.30	4.20	2.50	1.87	1.80	2.00	2.35	2.45
27	2.42	2.60	4.30	6.90	8.40	4.15	2.40	1.87	1.77	2.10	2.35	2.50
28	2.40	2.70	5.30	6.60	8.45	4.15	2.35	1.87	1.77	2.15	2.30	2.40
29	2.40	.....	7.30	6.70	8.35	4.30	2.20	1.87	1.77	2.05	2.25	2.40
30	2.42	.....	6.90	6.70	8.10	4.25	2.30	1.85	1.75	2.05	2.30	2.40
31	2.40	.....	6.10	.....	7.90	.....	2.25	1.85	.....	2.10	.....	2.40

BATTLE MOUNTAIN STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 302, is located at the county highway bridge, three-fourths of a mile northeast of the town of Battle Mountain, Nevada. C. R. Taylor is the observer. The gage is vertical and is spiked to the timber wing wall immediately above the bridge, on the left bank. The bench mark is on a spike in the tie beam at the east side of the bridge near the south end, at an elevation of 10 feet above zero on the gage. The channel is curved at this point and the banks are low and liable to overflow at high water. There are also several sloughs or side channels, so at extreme high water it is difficult to obtain an accurate measurement of the flow of the stream. The bed of the stream is of sand and gravel and shifts considerably. The following discharge measurements were made in 1897 by L. H. Taylor:

March 17, gage height, 2.85 feet; discharge, 276 second-feet.
April 4, gage height, 6.10 feet; discharge, 944 second-feet.
April 10, gage height, 7.10 feet; discharge, 1,557 second-feet.
April 15, gage height, 8.30 feet; discharge, 2,454 second-feet.
May 26, gage height, 8.60 feet; discharge, 2,870 second-feet.
June 24, gage height, 6.70 feet; discharge, 1,394 second-feet.
July 6, gage height, 4.70 feet; discharge, 711 second-feet.
July 21, gage height, 2.55 feet; discharge, 306 second-feet.
August 20, gage height, 0.85 foot; discharge, 16 second-feet.
September 23, gage height, 0.45 foot; discharge, 4 second-feet.

Daily gage height, in feet, of Humboldt River at Battle Mountain, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	2.30	2.45	5.80	8.58	8.76	5.25	1.60	0.60	0.55	1.55	2.00
2	2.20	2.30	2.45	6.60	8.58	8.80	5.10	1.50	.55	.55	1.55	2.00
3	2.25	2.30	2.40	6.90	8.57	8.76	5.00	1.45	.50	.55	1.60	2.00
4	2.25	2.35	2.40	6.10	8.56	8.73	4.90	1.40	.50	.60	1.60	2.05
5	2.25	2.35	2.50	6.10	8.56	8.70	4.80	1.30	.50	.60	1.60	2.05
6	2.15	2.20	2.50	6.15	8.55	8.66	4.70	1.25	.50	.65	1.65	2.05
7	2.15	2.35	2.50	6.30	8.54	8.60	4.60	1.20	.50	.65	1.65	2.00
8	2.10	2.30	2.70	6.50	8.55	8.56	4.50	1.20	.50	.75	1.65	2.10
9	2.10	2.30	2.85	6.90	8.56	8.45	4.40	1.15	.50	1.20	1.65	2.10
10	2.20	2.35	2.60	7.20	8.57	8.30	4.20	1.15	.50	1.20	1.65	2.10
11	2.20	2.35	2.45	7.60	8.58	8.10	4.00	1.10	.50	1.00	1.70	2.20
12	2.20	2.35	2.45	7.90	8.59	7.95	3.85	1.10	.50	.90	1.70	2.35
13	2.20	2.35	2.50	8.10	8.60	7.80	3.75	1.05	.50	.90	1.70	2.40
14	2.20	2.35	2.60	8.25	8.55	7.70	3.40	1.05	.50	.90	1.70	2.40
15	2.20	2.40	2.70	8.35	8.54	7.65	3.20	1.05	.50	.95	1.70	2.50
16	2.20	2.40	2.80	8.42	8.54	7.60	3.40	1.00	.50	.95	1.70	2.80
17	2.10	2.45	2.85	8.47	8.52	7.55	4.80	1.00	.50	1.00	1.70	2.70
18	2.10	2.50	2.90	8.50	8.50	7.50	2.90	.95	.45	1.00	1.75	2.70
19	2.20	2.45	2.90	8.55	8.47	7.45	2.75	.90	.45	1.10	1.75	2.70
20	2.15	2.45	2.90	8.60	8.45	7.30	2.65	.90	.45	1.10	1.75	2.50
21	2.15	2.40	2.65	8.63	8.47	7.15	2.55	.85	.45	1.15	1.75	2.55
22	2.10	2.40	2.30	8.67	8.50	7.00	2.40	.85	.45	1.20	1.80	2.70
23	2.00	2.40	3.00	8.70	8.52	6.85	2.30	.80	.45	1.25	1.80	2.70
24	2.00	2.35	2.80	8.73	8.55	6.70	2.20	.80	.45	1.30	1.80	2.70
25	2.10	2.35	3.00	8.70	8.58	6.40	2.10	.75	.45	1.30	1.85	2.75
26	2.10	2.35	3.10	8.70	8.60	6.20	2.00	.75	.45	1.35	1.85	2.75
27	2.15	2.35	2.90	8.68	8.62	6.00	2.00	.70	.50	1.40	1.90	2.75
28	2.15	2.40	3.00	8.65	8.65	5.80	1.90	.70	.50	1.40	1.95	2.75
29	2.20	.....	3.30	8.63	8.68	5.60	1.85	.65	.50	1.45	1.90	2.80
30	2.20	.....	3.70	8.60	8.70	5.40	1.75	.65	.50	1.50	1.95	2.80
31	2.20	.....	5.00	.....	8.73	.....	1.70	.60	.....	1.50	.....	2.90

GOLCONDA STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 303, is located 1¼ miles northerly from the town of Golconda, Nevada. The observer is L. Dutertre, a farmer and merchant. The gage is vertical and is spiked to posts driven into the left bank of the river. There are two bench marks, one on a 2 by 4 inch post driven flush with the ground surface 20 feet from the gage, and the other on a large spike driven into a post which is firmly set about 15 feet from the gage. The first is at an elevation of 10.55 feet and the second 13.70 feet above zero on the gage. Measurements are made from a cable and suspended car. The channel is nearly straight for about 400 feet. The banks are moderately high, but liable to overflow at extreme flood stages, perhaps once in four or five years. The bed of the stream is of gravel and sand, shifting somewhat. The following discharge measurements were made in 1897 by L. H. Taylor:

March 24, gage height, 2.80 feet; discharge, 207 second-feet.
April 9, gage height, 5.30 feet; discharge, 650 second-feet.
April 21, gage height, 7.05 feet; discharge, 1,363 second-feet.
June 2, gage height, 9.20 feet; discharge, 2,608 second-feet.
June 27, gage height, 6.87 feet; discharge, 1,198 second-feet.
July 5, gage height, 5.65 feet; discharge, 796 second-feet.
July 30, gage height, 2.90 feet; discharge, 251 second-feet.
August 10, gage height, 1.94 feet; discharge, 124 second-feet.
September 13, gage height, 0.70 foot; discharge, 7 second-feet.
November 2, gage height, 1.20 feet; discharge, 43 second-feet.
November 27, gage height, 1.75 feet; discharge, 89 second-feet.

Daily gage height, in feet, of Humboldt River at Golconda, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	2.50	2.85	3.80	9.95	9.20	6.20	2.70	1.10	0.50	1.10	2.00
2	2.20	2.40	2.90	4.40	9.95	9.25	5.90	2.60	1.00	.50	1.20	2.00
3	2.20	2.45	2.90	4.80	10.00	9.25	5.90	2.50	1.00	.50	1.25	2.00
4	2.20	2.50	2.95	5.00	9.90	9.30	5.70	2.40	1.00	.50	1.30	2.00
5	2.20	2.65	2.85	5.10	9.90	9.40	5.60	2.30	1.00	.50	1.40	2.00
6	2.20	2.60	2.80	5.40	9.80	9.50	5.50	2.25	1.00	.50	1.45	2.10
7	2.20	2.50	2.80	5.40	9.75	9.55	5.35	2.20	.95	.50	1.50	2.10
8	2.20	2.50	2.85	5.40	9.70	9.65	5.20	2.15	.90	1.80	1.50	2.20
9	2.20	2.60	2.90	5.30	9.60	9.75	5.15	2.10	.85	1.50	1.50	2.30
10	2.20	2.60	2.90	5.40	9.55	9.65	4.95	1.95	.80	1.30	1.55	2.40
11	2.20	2.65	3.20	5.50	9.50	9.55	4.90	1.85	.80	1.30	1.55	2.45
12	2.20	2.70	2.10	5.70	9.50	9.40	4.85	1.80	.75	1.20	1.55	2.50
13	2.25	2.70	2.00	5.75	9.50	9.40	5.85	1.75	.70	1.20	1.55	2.50
14	2.30	2.70	2.90	5.80	9.50	9.20	4.80	1.70	.70	1.10	1.60	2.50
15	2.30	2.80	2.90	5.90	9.50	9.00	4.60	1.65	.70	1.00	1.60	2.60
16	2.30	2.90	2.90	6.10	9.50	8.80	4.40	1.65	.70	.90	1.65	2.60
17	2.30	3.00	2.90	6.40	9.50	8.60	4.20	1.60	.70	.80	1.65	2.65
18	2.30	3.00	2.80	6.50	9.50	8.40	4.00	1.55	.70	.80	1.65	2.65
19	2.25	2.90	2.85	6.80	9.50	8.10	3.90	1.50	.70	.80	1.65	2.65
20	2.25	2.85	2.90	6.90	9.50	7.80	3.80	1.45	.70	.75	1.70	2.55
21	2.30	2.95	2.95	7.00	9.50	7.70	3.75	1.40	.65	.80	1.70	2.60
22	2.20	2.85	2.95	7.40	9.50	7.60	3.60	1.30	.65	.80	1.75	2.65
23	2.10	2.80	2.95	7.60	9.45	7.40	3.50	1.30	.65	.80	1.75	2.65
24	2.15	2.70	2.90	8.00	9.40	7.20	3.40	1.35	.60	.80	1.85	2.65
25	2.20	2.70	3.00	8.10	9.30	7.20	3.45	1.40	.60	.80	1.90	2.70
26	2.30	2.75	3.50	8.50	9.30	7.00	3.30	1.40	.60	.85	1.95	2.70
27	2.80	2.90	3.50	8.80	9.30	6.90	3.20	1.35	.60	.95	1.90	2.70
28	2.70	2.80	3.10	9.15	9.25	6.70	3.10	1.35	.55	.95	1.90	2.70
29	2.40	.....	3.10	9.50	9.20	6.60	3.00	1.30	.55	.90	1.90	2.70
30	2.30	.....	3.30	9.80	9.10	6.40	2.90	1.25	.55	1.00	1.95	2.70
31	2.35	.....	3.50	.....	9.15	.....	2.80	1.20	.....	1.00	.....	2.75

OREANA STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 306, is located at the old Oreana highway bridge, about 12 miles northeast of Lovelocks, Nevada. The observer is Joe Rodgers, section foreman of the Central Pacific Railroad. The bridge abutment to which the gage was fastened was undermined and fell May 26, 1897. A temporary gage was used until September 8, 1897, when a new inclined one was placed on the left bank of the river about a mile and a half above the site of the old gage and opposite the section house. It is made of a 2 by 4 inch pine timber spiked to posts driven well into the bank. The bench mark is a 10 by 10 inch post near the left bank of the river about 40 feet below the gage, and its elevation is 10.0 feet above the zero. The channel here is straight for about 500 feet above the gage and for about 150 feet below. The station is provided with a cable and car. The river banks are high and not liable to overflow. The bed of the stream is sandy and shifting. The following measurements were made in 1897 by L. H. Taylor:

March 25, gage height, 3.85 feet; discharge, 203 second-feet.
April 22, gage height, 6.70 feet; discharge, 1,037 second-feet.
April 30, gage height, 9.35 feet; discharge, 1,939 second-feet.
May 14, gage height, 11.70 feet; discharge, 2,932 second-feet.
June 26, gage height, 8.75 feet; discharge, 1,910 second-feet.
July 9, gage height, 6.80 feet; discharge, 1,169 second-feet.
July 22, gage height, 5.00 feet; discharge, 625 second-feet.
September 9, gage height, 2.50 feet; discharge, 59 second-feet.
November 7, gage height, 2.10 feet; discharge, 25 second-feet.

Daily gage height, in feet, of Humboldt River at Oreana, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.30	3.80	4.50	9.80	10.60	8.10	4.20	2.60	2.30	2.05	2.45
2	2.80	3.30	3.80	4.60	9.90	10.40	7.85	4.10	2.55	2.30	2.05	2.50
3	2.80	3.20	3.90	4.60	10.30	10.30	7.60	4.10	2.55	2.30	2.05	2.55
4	2.80	3.30	3.80	4.70	10.50	10.20	7.40	4.10	2.55	2.30	2.10	2.60
5	2.90	3.40	3.80	4.80	10.80	10.10	7.20	4.00	2.55	2.30	2.10	3.10
6	2.90	3.40	3.80	4.90	11.00	10.10	7.10	3.90	2.50	2.25	2.10	3.00
7	2.90	3.40	3.80	5.00	11.20	10.10	7.00	3.90	2.50	2.35	2.10	2.90
8	2.90	3.40	3.80	5.10	11.40	10.00	6.95	3.80	2.50	2.50	2.10	2.95
9	2.95	3.50	3.85	5.20	11.70	9.90	6.80	3.80	2.50	2.40	2.15	2.70
10	2.90	3.50	3.80	5.20	11.80	9.90	6.60	3.70	2.50	2.35	2.15	2.70
11	2.90	3.40	3.90	5.20	11.90	9.80	6.40	3.60	2.45	2.30	2.15	2.75
12	2.90	3.40	3.90	5.30	12.00	9.80	6.30	3.50	2.45	2.80	2.15	2.75
13	3.00	3.50	3.85	5.40	11.90	9.80	6.10	3.40	2.45	2.30	2.20	2.80
14	3.00	3.50	3.80	5.40	11.75	9.80	6.00	3.40	2.45	2.30	2.20	2.80
15	3.00	3.50	3.80	5.60	11.80	9.80	5.90	3.30	2.45	2.25	2.20	2.80
16	3.00	3.50	3.90	5.80	11.60	9.80	5.80	3.20	2.45	2.25	2.25	2.80
17	3.10	3.50	3.80	5.80	11.40	9.80	5.60	3.10	2.40	2.25	2.25	2.85
18	3.10	3.50	3.85	5.90	11.20	9.70	5.50	3.10	2.40	2.20	2.25	2.85
19	3.10	3.60	3.80	6.00	11.00	9.70	5.40	3.10	2.40	2.20	2.25	2.85
20	3.10	3.60	3.80	6.40	11.00	9.60	5.20	3.10	2.40	2.20	2.30	2.80
21	3.10	3.60	3.80	6.50	10.90	9.40	5.10	3.10	2.40	2.20	2.30	2.90
22	3.20	3.60	3.80	6.80	10.90	9.30	5.00	3.00	2.40	2.15	2.30	2.90
23	3.20	3.70	3.80	7.10	10.90	9.00	4.90	3.00	2.40	2.15	2.20	2.90
24	3.20	3.70	3.85	7.50	10.90	8.90	4.80	2.90	2.40	2.15	2.30	2.90
25	3.30	3.70	3.85	8.05	10.90	8.80	4.80	2.80	2.40	2.15	2.35	2.95
26	3.30	3.80	3.90	8.50	10.90	8.70	4.70	2.70	2.35	2.10	2.35	2.95
27	3.20	3.80	3.90	8.80	10.90	8.60	4.60	2.70	2.35	2.10	2.40	3.00
28	3.20	3.80	4.00	9.10	10.90	8.50	4.50	2.60	2.35	2.10	2.40	3.00
29	3.30	.....	4.10	9.30	10.90	8.40	4.40	2.60	2.35	2.05	2.45	3.00
30	3.40	.....	4.30	9.50	10.80	8.20	4.30	2.60	2.30	2.05	2.45	3.05
31	3.30	.....	4.45	.....	10.80	.....	4.20	2.60	.....	2.05	.....	3.05

MASON'S RANCH STATION ON SOUTH FORK OF HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 311, is located at a point on the South Fork of Humboldt River, about 10 miles southwest of the town of Elko, Nevada, and about 6 miles above its junction with the main stream. The observer is Martin Mason, a farmer. The gage is inclined and spiked to posts driven firmly into the right bank. There is one bench mark on a 2 by 4 inch post 2½ feet long driven flush with the ground 10 feet north of the gage, and having an elevation of 7.50 feet above zero on the gage. Measurements are made from a cable and suspended car at a point 1 mile above the gage, the latter being placed, for the convenience of the observer, near his farm. At the point of measurement the banks are high and the channel is straight for over 600 feet. The bed of the stream is of rock and gravel and is quite stable. The following discharge measurements were made in 1897 by L. H. Taylor:

April 6, gage height, 1.95 feet; discharge, 139 second-feet.
May 7, gage height, 5.00 feet; discharge, 1,128 second-feet.
June 9, gage height, 3.65 feet; discharge, 800 second-feet.
June 22, gage height, 2.30 feet; discharge, 363 second-feet.
July 11, gage height, 1.75 feet; discharge, 211 second-feet.
July 25, gage height, 1.20 feet; discharge, 102 second-feet.
September 24, gage height, 0.35 foot; discharge, 5 second-feet.
October 10, gage height, 0.60 foot; discharge, 19 second-feet.
November 29, gage height, 0.90 foot; discharge, 56 second-feet.

Daily gage height, in feet, of South Fork of Humboldt River at Mason's ranch, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.20	1.30	2.20	4.00	4.25	2.05	0.90	0.30	0.40	0.80	1.00
2	1.20	1.30	1.30	1.85	4.05	3.90	2.00	.85	.30	.45	.80	1.20
3	1.25	1.25	1.20	1.80	4.15	3.70	2.25	.85	.30	.45	.80	.80
4	1.25	1.30	1.20	1.80	4.30	3.55	2.10	1.35	.30	.45	.85	.55
5	1.30	1.40	1.25	1.95	4.50	3.40	2.00	1.30	.30	.45	.85	.90
6	1.20	1.50	1.30	1.95	4.80	3.30	1.95	1.00	.30	.45	.85	1.00
7	1.20	1.40	1.25	2.10	5.00	3.30	1.90	.90	.30	.45	.85	1.10
8	1.10	1.35	1.20	2.20	4.90	3.40	1.85	.85	.30	.50	.85	1.10
9	1.00	1.30	1.20	2.20	4.55	3.65	1.80	.75	.30	.50	.85	1.00
10	.85	1.40	1.25	2.60	4.30	3.60	1.75	.70	.30	.60	.85	1.25
11	1.00	1.50	1.30	2.90	4.15	3.35	1.75	.65	.30	.60	.85	1.15
12	1.10	1.25	1.30	2.85	4.00	3.25	1.70	.65	.30	.60	.90	1.20
13	1.10	1.45	1.30	2.95	3.95	3.20	1.65	.60	.35	.60	.90	1.10
14	1.15	1.50	1.20	3.05	4.10	3.20	1.60	.60	.35	.70	.90	1.05
15	1.10	1.25	1.20	3.30	4.25	3.35	1.65	.55	.35	.80	.80	1.00
16	1.20	1.30	1.25	3.50	4.45	3.25	1.65	.50	.35	.80	.85	1.00
17	.80	1.40	1.40	3.70	4.55	3.30	1.55	.45	.35	.80	1.15	1.00
18	.75	1.40	1.35	4.20	4.70	2.90	1.50	.45	.35	.80	.90	1.00
19	1.00	1.50	1.30	4.20	4.80	2.75	1.40	.45	.35	.75	.85	.95
20	1.10	1.55	1.30	4.50	4.80	2.55	1.20	.40	.35	.75	.85	.90
21	1.10	1.40	1.35	4.40	5.20	2.45	1.10	.40	.35	.75	.90	.90
22	1.15	1.45	1.25	4.20	5.20	2.25	1.10	.40	.35	.75	.95	1.00
23	1.10	1.40	1.35	3.60	5.40	2.25	1.15	.40	.35	.80	.95	1.00
24	1.15	1.50	1.65	3.40	5.45	2.25	1.10	.35	.35	.90	.95	.90
25	1.20	1.30	2.40	3.30	5.50	2.20	1.15	.35	.35	.90	.90	.90
26	1.20	1.25	2.40	3.30	5.40	2.20	1.20	.35	.35	.85	1.50	1.00
27	.80	1.25	2.25	3.50	5.05	2.20	1.10	.35	.35	.80	1.60	1.00
28	1.20	1.30	3.20	3.75	4.75	2.10	1.05	.45	.35	.80	1.10	.90
29	1.20	.....	3.50	3.85	4.60	2.00	1.00	.35	.40	.80	.95	.90
30	1.20	.....	3.20	3.95	4.55	1.95	.95	.35	.40	.80	.90	.95
31	1.20	.....	2.70	.....	4.60	.....	.95	.30	....	.80	.....	.90

BATTLE CREEK STATION ON BEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 313, is located 5 miles northwest of Preston, Idaho. The observer is John A. Nelson. The station is equipped with a cable and car. The gage consists of a vertical board nailed to a pile. The bench mark is a nail in the southeast corner of the house near the gage, about 1.5 feet from the ground, and it is 10.95 feet above the zero of the gage. The following discharge measurements were made by Samuel Fortier and others in 1897:

May 20, gage height, 5.05 feet; discharge, 5,700 second-feet.
June 17, gage height, 3.50 feet; discharge, 2,527 second-feet.
June 17, gage height, 3.50 feet; discharge, 2,969 second-feet.
July 28, gage height, 1.75 feet; discharge, 917 second-feet.
August 23, gage height, 1.57 feet; discharge, 692 second-feet.
October 29, gage height, 1.90 feet; discharge, 1,027 second-feet.

Daily gage height, in feet, of Bear River at Battle Creek, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	1.70	.....	4.00	5.00	2.50	1.70	1.60	1.60	1.90	1.90
2	1.80	.....	.....	.....	4.10	4.90	2.50	1.70	1.60	1.90	1.90	1.90
3	.....	.....	.....	2.00	4.20	4.80	2.45	1.70	1.80	1.80	1.90	1.90
4	.....	1.70	.....	.....	4.20	4.70	2.40	1.70	1.70	1.80	1.90	1.80
5	.....	.....	.....	.....	4.30	4.70	2.40	1.70	1.60	1.80	1.90	1.70
6	1.80	1.70	1.70	.....	4.40	4.70	2.40	1.70	1.60	1.80	1.90	1.80
7	.....	.....	.....	.....	4.50	4.60	2.40	1.70	1.60	1.80	1.90	1.90
8	.....	.....	.....	.....	4.50	4.60	2.40	1.70	1.60	1.80	1.90	1.90
9	1.80	1.70	.....	.....	4.50	4.50	2.30	1.70	1.60	1.80	1.90	1.90
10	.....	.....	.....	2.50	4.50	4.40	2.20	1.70	1.60	1.80	1.90	1.80
11	.....	.....	.....	2.60	4.60	4.40	2.20	1.70	1.60	1.80	1.90	1.90
12	.....	.....	1.70	2.70	4.60	4.40	2.20	1.70	1.60	1.80	1.90	1.90
13	.....	.....	.....	2.80	4.60	4.30	2.20	1.70	1.60	2.00	1.90	1.80
14	.....	.....	.....	2.90	4.60	4.30	2.20	1.70	1.60	2.20	1.90	1.70
15	.....	.....	1.70	3.00	4.60	4.20	2.20	1.70	1.60	2.20	1.90	1.80
16	1.80	.....	.....	3.10	4.90	4.10	2.20	1.70	1.60	2.10	1.90	1.80
17	.....	.....	.....	3.20	5.00	3.50	2.10	1.70	1.60	2.00	1.90	1.70
18	.....	.....	.....	3.30	5.00	3.40	2.00	1.70	1.60	2.00	1.90	1.65
19	.....	.....	.....	3.40	5.00	3.30	2.00	1.70	1.60	2.00	1.90	1.60
20	.....	1.70	1.70	3.50	5.10	3.20	2.00	1.70	1.60	2.00	1.90	1.70
21	.....	.....	.....	3.60	5.10	3.10	2.00	1.60	1.60	2.00	2.00	1.70
22	.....	.....	.....	3.70	5.15	3.00	1.90	1.60	1.60	2.00	2.00	1.80
23	1.80	.....	.....	3.80	5.20	3.00	1.90	1.60	1.60	2.00	2.10	1.80
24	.....	.....	.....	3.90	5.15	3.00	1.80	1.60	1.60	2.00	2.10	1.80
25	.....	.....	.....	4.00	5.20	2.90	1.90	1.60	1.60	2.00	2.00	1.80
26	.....	.....	.....	4.20	5.25	2.90	1.80	1.60	1.60	2.00	2.00	1.80
27	.....	1.70	.....	4.30	5.30	2.80	1.80	1.60	1.60	2.00	2.00	1.80
28	.....	.....	.....	4.40	5.25	2.65	1.80	1.60	1.60	2.00	2.00	1.80
29	.....	.....	2.00	4.30	5.15	2.60	1.80	1.60	1.60	1.90	2.00	1.80
30	1.70	.....	.....	4.20	5.10	2.55	1.80	1.60	1.60	1.90	2.00	1.90
31	.....	.....	.....	.....	5.10	.....	1.80	1.60	.....	1.90	.....	1.90

LOGAN STATION ON LOGAN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 316, is located in the river canyon about 2 miles east of the city of Logan, Utah. The gage is a vertical iron post set firmly into the ground and graduated to tenths of a foot. The equipment consists of a cable, car, and tag wire. The observer is J. S. Pehrson, living about one-half mile from the gage. The bench mark is a stone 35 feet northeast of the end of the cable on the north side of the river. The elevation is 14.01 feet above datum. The point of the rock and the letters "B. M." are marked with red paint. The following discharge measurements were made by Samuel Fortier and others in 1897:

May 7, gage height, 4.13 feet; discharge, 1,210 second-feet.
May 29, gage height, 4.60 feet; discharge, 1,336 second-feet.
June 17, gage height, 4.15 feet; discharge, 1,097 second-feet.
July 20, gage height, 3.20 feet; discharge, 478 second-feet.
July 26, gage height, 3.10 feet; discharge, 413 second-feet.
August 21, gage height, 2.85 feet; discharge, 305 second-feet.
August 30, gage height, 2.80 feet; discharge, 298 second-feet.
September 13, gage height, 2.80 feet; discharge, 284 second-feet.
November 12, gage height, 2.66 feet; discharge, 219 second-feet.
November 16, gage height, 2.66 feet; discharge, 219 second-feet.

Daily gage height, in feet, of Logan River at Logan, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	.....	.....	.....	3.80	4.75	3.50	3.05	2.80	2.80	2.70	2.65
2	.....	.....	.....	2.45	3.90	4.65	3.60	3.05	2.80	2.80	2.70	2.65
3	.....	.....	.....	.....	4.10	4.45	3.55	3.00	2.90	2.80	2.70	2.65
4	.....	.....	.....	.....	4.20	4.30	3.50	3.00	2.85	2.80	2.70	2.60
5	.....	2.45	2.40	.....	4.10	4.25	3.45	3.00	2.75	2.75	2.70	2.60
6	.....	.....	.....	.....	4.20	4.15	3.45	3.00	2.75	2.75	2.70	2.60
7	.....	.....	.....	.....	4.15	4.15	3.45	3.00	2.75	2.75	2.70	2.60
8	.....	.....	.....	.....	3.95	4.20	3.40	3.05	2.75	2.75	2.65	2.60
9	2.45	.....	.....	2.50	3.80	4.20	3.35	3.00	2.75	2.75	2.65	2.55
10	.....	.....	.....	.....	3.80	4.15	3.35	3.00	2.75	2.75	2.65	2.60
11	.....	.....	.....	.....	3.75	4.10	3.30	2.75	2.75	2.75	2.70	2.60
12	.....	2.45	2.40	.....	3.80	4.10	3.30	2.75	2.75	2.75	2.70	2.60
13	.....	.....	.....	.....	3.90	4.05	3.25	2.75	2.75	2.75	2.70	2.60
14	.....	.....	.....	.....	4.10	4.05	3.25	2.95	2.75	2.75	2.70	2.60
15	.....	.....	.....	2.75	4.15	4.05	3.25	2.95	2.75	2.75	2.65	2.55
16	2.45	.....	.....	2.80	4.20	4.10	3.25	2.95	2.75	2.75	2.65	2.55
17	.....	.....	.....	2.95	4.00	4.00	3.25	2.90	2.75	2.75	2.65	2.55
18	.....	.....	.....	3.05	4.20	3.85	3.20	2.90	2.75	2.75	2.65	2.55
19	.....	2.45	2.40	3.40	4.40	3.80	3.20	2.90	2.75	2.75	2.65	2.50
20	.....	.....	.....	3.35	4.90	3.75	3.20	2.90	2.75	2.75	2.65	2.50
21	.....	.....	.....	3.15	4.90	3.75	3.20	2.85	2.75	2.75	2.65	2.50
22	2.45	.....	.....	3.05	4.75	3.75	3.15	2.85	2.75	2.75	3.65	2.50
23	.....	.....	.....	2.95	4.80	3.75	3.15	2.85	2.75	2.75	2.65	2.50
24	.....	.....	.....	2.90	4.80	3.75	3.10	2.85	2.80	2.80	2.65	2.45
25	.....	.....	.....	3.00	4.80	3.70	3.10	2.85	2.75	2.75	2.65	2.50
26	.....	2.40	2.50	3.15	4.80	3.65	3.10	2.85	2.75	2.70	2.65	2.50
27	.....	.....	.....	3.35	4.70	3.65	3.10	2.85	2.75	2.70	2.65	2.55
28	.....	.....	.....	3.50	4.55	3.60	3.10	2.85	2.75	2.70	2.65	2.50
29	2.45	.....	.....	3.70	4.50	3.55	3.05	2.85	2.75	2.70	2.65	2.55
30	.....	.....	.....	3.75	4.55	3.55	3.05	2.80	2.75	2.70	2.65	2.55
31	.....	.....	.....	.....	4.70	.....	3.05	2.80	.....	2.70	.....	2.50

COLLINSTON STATION ON BEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 319, is located in the canyon below Cache Valley, Utah, about 4 miles from the railroad station of Collinston or 2 miles east of the town of Fielding, Utah. The observer is Robert Anglesey, who is the ditch rider of the Bear River Canal and lives near the station. The gage consists of a vertical iron rod, graduated to tenths of a foot. The bench mark is a nail in an oak post 20 feet west of the gage and 20 feet north of the cable. Its elevation is 7.35 feet above the zero of the gage. The chief source of error at this station is the large rocks which are scattered over the bed. The following discharge measurements were made in 1897 by T. H. Humphreys and W. B. Dougall:

May 3, gage height, 5.95 feet; discharge, 8,344 second-feet.
May 3, gage height, 5.95 feet; discharge, 8,445 second-feet.
May 28, gage height, 6.60 feet; discharge, 10,241 second-feet.
June 19, gage height, 4.03 feet; discharge, 3,822 second-feet.
July 28, gage height, 1.80 feet; discharge, 1,274 second-feet.
August 16, gage height, 1.70 feet; discharge, 1,084 second-feet.

Daily gage height, in feet, of Bear River at Collinston, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	2.00	2.60	6.00	6.30	3.00	1.70	1.60	1.90	2.20	1.85
2	.....	2.00	.....	2.40	6.00	6.20	3.00	1.70	1.60	1.90	2.10	1.85
3	.....	.....	2.00	2.30	5.90	6.10	3.00	1.70	1.60	1.90	2.10	1.85
4	1.60	2.00	.....	2.60	6.00	6.00	2.95	1.70	1.65	1.85	2.10	1.85
5	.....	.....	2.00	3.00	6.00	5.90	2.90	1.70	1.70	1.85	2.10	1.95
6	1.80	2.00	2.00	3.40	6.20	5.80	2.85	1.70	1.80	1.90	2.00	1.95
7	.....	.....	.....	3.50	6.40	5.60	2.80	1.70	1.80	2.00	1.90	1.95
8	.....	2.10	2.00	3.60	6.50	5.40	2.65	1.70	1.80	2.10	1.80	1.95
9	2.20	.....	.....	3.80	6.60	5.20	2.55	1.70	1.80	2.15	1.80	2.05
10	.....	2.20	2.00	4.00	6.40	5.10	2.50	1.70	1.80	2.20	1.80	2.05
11	2.10	.....	.....	4.60	6.20	5.00	2.45	1.70	1.80	2.25	1.80	2.05
12	.....	2.00	.....	5.00	6.10	4.90	2.40	1.70	1.80	2.30	1.80	2.15
13	.....	2.00	2.00	4.80	6.00	4.90	2.35	1.70	1.85	2.35	1.80	2.25
14	2.20	.....	2.00	4.80	6.00	4.80	2.30	1.70	1.85	2.40	1.90	2.20
15	.....	2.00	2.00	4.80	6.00	4.60	2.20	1.70	1.85	2.45	1.90	2.25
16	2.00	.....	2.00	4.80	6.10	4.70	2.15	1.65	1.85	2.50	1.90	2.25
17	.....	2.00	2.00	4.80	6.15	4.60	2.10	1.65	1.90	2.50	1.90	2.25
18	2.00	.....	2.00	5.00	6.20	4.40	2.00	1.65	1.85	2.50	1.90	2.20
19	.....	.....	2.00	5.20	6.30	4.20	2.00	1.60	1.85	2.45	1.90	2.20
20	1.90	2.00	2.00	5.40	6.50	4.00	2.00	1.60	1.80	2.45	1.90	2.20
21	.....	.....	2.00	5.60	6.60	3.80	2.00	1.60	1.80	2.50	1.90	2.30
22	.....	2.00	2.00	5.70	6.70	3.60	2.00	1.60	1.80	2.50	1.90	2.10
23	2.00	.....	2.00	5.90	6.80	3.50	2.00	1.60	1.80	2.50	1.90	2.45
24	2.00	2.00	2.00	6.10	6.80	3.40	2.00	1.55	1.80	2.50	1.90	2.40
25	.....	.....	2.00	5.80	6.80	3.80	2.00	1.55	1.80	2.50	1.90	2.65
26	2.00	.....	2.10	5.70	6.80	3.20	2.00	1.55	1.80	2.45	1.90	2.60
27	.....	2.00	2.20	5.70	6.70	3.10	1.90	1.55	1.80	2.45	1.90	2.80
28	2.00	.....	2.20	5.80	6.70	3.05	1.85	1.50	1.85	2.40	1.85	2.20
29	.....	.....	2.60	5.90	6.60	3.00	1.80	1.50	1.85	2.35	1.90	2.15
30	2.00	.....	3.00	5.95	6.55	3.00	1.75	1.50	1.90	2.30	1.85	2.15
31	.....	.....	2.80	.....	6.40	.....	1.70	1.55	.....	2.20	.....	2.20

OGDEN STATION ON OGDEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 316, was located about 10 miles east of the city of Ogden, Utah, at the upper end of the canyon. Owing to the presence of the dam of the Pioneer Electric Power Company, constructed in 1896, just below this location, water was backed up and ponded around the gage. In the spring of 1897, therefore, the station was moved down the river 5 miles to near a powder mill in the canyon. The station is equipped with cable, car and tag wire. The gage is inclined and divided into tenths of a foot. The bench mark is a point on a quartzite ledge, one foot above the ground, at edge of county road, 37 feet west and 25 feet south of gage, and its elevation is 11.14 feet above the zero. The observer is Frank Hart. The following discharge measurements were made in 1897 by Samuel Fortier and W. B. Dougall.

May 11, gage height, 6.69 feet; discharge, 1,890 second-feet.
May 26, gage height, 5.79 feet; discharge, 1,423 second-feet
June 2, gage height, 4.79 feet; discharge, 682 second-feet.
June 26, gage height, 3.25 feet; discharge, 170 second-feet.
July 30, gage height, 2.80 feet; discharge, 74 second-feet.
September 15, gage height, 2.61 feet; discharge, 51 second-feet.
October 15, gage height, 2.68 feet; discharge, 78 second-feet.

Daily gage height, in feet, of Ogden River near Ogden, Utah, for 1897.

Day.	Jan.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	4.90	3.60	2.70	2.60	2.80	2.70	2.70
2	.....	.....	4.80	3.50	2.70	2.60	2.70	2.70	2.70
3	.....	.....	4.70	3.40	2.70	2.70	2.70	2.70	2.70
4	.....	.....	4.50	3.30	2.60	2.60	2.70	2.70	2.60
5	.....	.....	4.50	3.30	2.60	2.60	2.60	2.80	2.60
6	.....	.....	4.40	3.30	2.60	2.60	2.70	2.70	2.60
7	3.45	.....	4.40	3.20	2.60	2.60	2.70	2.70	2.60
8	.....	.....	4.40	3.20	2.60	2.60	2.70	2.70	2.60
9	.....	.....	4.30	3.20	2.60	2.60	2.70	2.70	2.70
10	.....	6.70	4.20	3.10	2.60	2.60	2.70	2.70	2.60
11	.....	6.70	4.10	3.00	2.60	2.60	2.70	2.70	2.60
12	.....	6.50	4.00	3.00	2.60	2.60	2.80	2.70	2.70
13	.....	6.60	3.90	3.00	2.60	2.70	2.70	2.70	2.60
14	2.80	6.80	3.90	2.90	2.60	2.60	2.80	2.70	2.60
15	.....	7.10	3.80	2.90	2.60	2.60	2.80	2.70	2.60
16	.....	6.80	4.10	2.90	2.60	2.60	2.70	2.70	2.60
17	.....	6.50	3.90	2.90	2.60	2.60	2.70	2.70	2.60
18	.....	6.40	3.90	2.90	2.60	2.60	2.70	2.70	2.50
19	.....	6.50	3.90	2.90	2.60	2.60	2.70	2.60	2.50
20	.....	7.10	3.90	2.90	2.60	2.60	2.70	2.60	2.40
21	.....	6.80	3.90	2.90	2.60	2.60	2.70	2.60	2.40
22	3.00	6.40	3.80	2.90	2.60	2.60	2.70	2.80	2.50
23	.....	6.20	3.70	2.80	2.60	2.60	2.70	2.70	2.40
24	.....	6.10	3.60	2.80	2.60	2.60	2.80	2.70	2.50
25	.....	5.90	3.50	2.80	2.60	2.60	2.70	2.80	2.40
26	.....	5.80	3.50	2.80	2.60	2.60	2.70	2.70	2.30
27	2.70	5.50	3.40	2.80	2.60	2.60	2.70	2.70	2.30
28	.....	5.20	3.40	2.70	2.60	2.60	2.70	2.70	2.60
29	.....	5.20	3.40	2.70	2.60	2.70	2.70	2.70	2.60
30	.....	5.10	3.60	2.70	2.60	2.60	2.70	2.70	2.60
31	.....	5.00	.....	2.70	2.60	.....	2.70	.....	2.60

UINTA STATION ON WEBER RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 323, is located near the watchman's house at the Union Pacific Railroad bridge, 5 miles east of Uinta, Utah. The observer is Morgan Flaherty, post-office address, Uinta, Utah. The gage consists of a horizontal timber, 4 by 4 inches by 16 feet long, fastened to two vertical posts set in the ground at the edge of the bank of the river, with one end of the timber projecting out over the water. On this horizontal timber is placed a wire gage. The bench mark consists of a spike driven into the first telegraph pole up the canyon from the gage, and its elevation is 17.44 feet above gage datum. The following discharge measurements were made in 1897 by W. B. Dougall and others:

April 29, gage height, 5.40 feet; discharge, 3,760 second-feet.
May 12, gage height, 5.25 feet; discharge, 3,662 second-feet.
May 27, gage height, 4.95 feet; discharge, 3,281 second-feet.
June 24, gage height, 2.20 feet; discharge, 805 second-feet.
July 29, gage height, 1.12 feet; discharge, 149 second-feet.
September 16, gage height, 1.40 feet; discharge, 250 second-feet.
October 15, gage height, 1.83 feet; discharge, 433 second-feet.

Daily gage height, in feet, of Weber River at Uinta, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.50	.....	.....	2.10	5.55	4.40	1.20	1.10	1.10	1.60	1.70	1.60
2	.....	1.50	1.40	2.20	5.65	4.40	1.20	1.10	1.10	1.60	1.70	1.60
3	.....	.....	.....	2.20	5.80	3.85	1.10	1.10	1.10	1.65	1.70	1.60
4	.....	.....	.....	2.45	6.10	3.55	1.20	1.10	1.10	1.80	1.70	1.60
5	1.50	1.50	1.40	2.65	6.45	3.85	1.20	1.10	1.10	1.80	1.70	1.60
6	.....	.....	.....	2.75	6.65	3.70	1.20	1.10	1.10	1.80	1.70	1.60
7	.....	.....	.....	2.75	6.90	3.45	1.20	1.10	1.20	1.80	1.70	1.60
8	.....	.....	1.60	2.70	6.75	3.05	1.20	1.10	1.20	1.80	1.70	1.60
9	1.50	1.50	.....	2.95	6.25	2.90	1.20	1.10	1.20	1.80	1.70	1.60
10	.....	.....	.....	3.50	5.65	2.90	1.20	1.10	1.20	1.80	1.70	1.60
11	.....	.....	.....	3.45	5.40	2.90	1.20	1.10	1.20	1.80	1.70	1.60
12	.....	1.50	1.60	3.65	5.30	2.75	1.20	1.10	1.20	1.80	1.70	1.60
13	.....	.....	.....	3.80	5.50	2.80	1.20	1.10	1.20	1.80	1.70	1.60
14	1.50	.....	1.50	3.85	5.80	2.70	1.20	1.10	1.20	1.80	1.70	1.60
15	.....	.....	1.50	4.05	5.90	2.55	1.20	1.10	1.20	1.80	1.70	1.60
16	.....	1.50	1.50	4.50	5.85	2.60	1.20	1.10	1.20	1.80	1.70	1.60
17	.....	.....	1.50	4.60	5.65	2.60	1.20	1.10	1.20	1.80	1.70	1.60
18	1.40	.....	1.50	4.85	5.65	2.60	1.10	1.10	1.20	1.80	1.70	1.60
19	1.40	1.50	1.50	5.30	5.65	2.60	1.10	1.10	1.30	1.80	1.70	1.60
20	.....	.....	1.50	5.70	5.85	2.45	1.10	1.10	1.30	1.80	1.70	1.60
21	.....	.....	1.60	5.35	5.75	2.30	1.10	1.10	1.30	1.80	1.60	1.60
22	.....	1.40	1.75	4.90	5.75	2.30	1.10	1.10	1.30	1.80	1.60	1.60
23	1.40	.....	1.80	4.50	5.55	2.20	1.10	1.10	1.30	1.80	1.60	1.60
24	.....	.....	1.85	4.05	5.55	2.10	1.10	1.10	1.30	1.80	1.60	1.60
25	1.50	1.40	2.10	3.85	5.50	2.10	1.10	1.10	1.30	1.80	1.60	1.60
26	.....	.....	2.50	4.10	5.25	2.10	1.10	1.10	1.35	1.80	1.60	1.45
27	.....	.....	2.70	4.70	4.95	1.90	1.10	1.10	1.40	1.80	1.60	1.50
28	.....	.....	2.75	5.15	4.45	1.65	1.10	1.10	1.40	1.80	1.60	1.45
29	1.50	.....	2.60	5.40	4.25	1.55	1.10	1.10	1.55	1.80	1.60	1.40
30	.....	.....	2.10	.....	4.45	1.45	1.10	1.10	1.60	1.80	1.60	1.40
31	.....	.....	2.10	.....	4.50	.....	1.10	1.10	.....	1.70	.....	1.40

PROVO STATION ON PROVO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 325, is located in the canyon about 6 miles from the city of Provo, Utah. The observer is Henry V. Smith, a farmer. The gage is inclined and fastened to stakes set in the ground. The bench mark is a stone firmly bedded in a bank near the wagon road, about 100 feet southwest of the gage. It is marked "B. M." in black paint, and is 6.95 feet above the zero of the gage. The banks are medium high. The channel is straight for some distance above and below the station. The bed of the river is gravelly and the velocity is medium swift. The following discharge measurements were made in 1897 by W. B. Dougall:

May 7, gage height, 6.25 feet; discharge, 1,818 second-feet.
May 14, gage height, 6.05 feet; discharge, 1,681 second-feet.
May 24, gage height, 6.53 feet; discharge, 2,454 second-feet.
June 4, gage height, 5.35 feet; discharge, 1,167 second feet.
June 21, gage height, 4.60 feet; discharge, 564 second-feet.
August 7, gage height, 4.10 feet; discharge, 306 second-feet.
November 26, gage height, 4.40 feet; discharge, 436 second-feet.

Daily gage height, in feet, of Provo River at Provo Canyon, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	5.60	5.80	4.30	4.00	4.00	4.40	4.50	4.40
2	4.40	.....	.....	.....	5.70	5.80	4.30	4.00	4.00	4.40	4.50	4.40
3	.....	.....	.....	.....	5.80	5.60	4.30	4.00	4.00	4.40	4.50	4.40
4	.....	.....	.....	4.80	5.90	5.50	4.20	4.00	4.00	4.40	4.50	4.40
5	.....	.....	.....	4.80	5.90	5.40	4.20	4.00	4.00	4.40	4.50	4.40
6	.....	4.60	4.40	4.80	6.00	5.20	4.20	4.00	4.00	4.40	4.50	4.40
7	.....	.....	.....	4.80	6.10	5.10	4.20	4.00	4.00	4.40	4.50	4.40
8	.....	.....	.....	4.80	6.10	5.10	4.20	4.00	4.00	4.40	4.50	4.30
9	4.40	.....	.....	4.80	6.20	5.10	4.20	4.00	4.00	4.40	4.50	4.30
10	.....	.....	.....	4.80	6.20	5.10	4.20	4.00	4.00	4.40	4.50	4.30
11	.....	.....	.....	5.00	5.90	5.00	4.20	4.00	4.10	4.40	4.50	4.30
12	.....	.....	.....	5.00	5.80	5.00	4.20	4.00	4.10	4.40	4.50	4.30
13	.....	4.60	4.40	5.00	6.00	5.00	4.20	4.00	4.10	4.40	4.50	4.30
14	.....	.....	.....	5.00	6.00	5.00	4.20	4.00	4.10	4.40	4.30	4.30
15	.....	.....	.....	5.00	6.20	4.90	4.20	4.00	4.10	4.40	4.30	4.30
16	.....	.....	.....	5.00	6.10	4.90	4.20	4.00	4.10	4.40	4.30	4.30
17	.....	.....	.....	5.00	6.10	4.90	4.20	4.00	4.10	4.50	4.30	4.30
18	.....	.....	.....	5.40	6.20	4.90	4.10	4.00	4.10	4.50	4.30	4.30
19	.....	4.80	.....	5.40	6.30	4.90	4.10	4.00	4.10	4.50	4.30	4.30
20	.....	4.60	4.40	5.60	6.30	4.80	4.10	4.00	4.10	4.50	4.30	4.30
21	.....	.....	.....	5.60	6.40	4.80	4.10	4.00	4.10	4.50	4.40	4.30
22	.....	.....	.....	5.40	6.50	4.60	4.10	4.00	4.10	4.50	4.40	4.30
23	4.30	.....	.....	5.00	6.50	4.50	4.10	4.00	4.10	4.50	4.40	4.30
24	.....	.....	.....	5.00	6.60	4.40	4.10	4.00	4.10	4.50	4.40	4.30
25	.....	.....	.....	5.10	6.60	4.30	4.10	4.00	4.10	4.50	4.40	4.30
26	.....	.....	.....	5.20	6.50	4.30	4.10	4.00	4.10	4.50	4.40	4.30
27	.....	4.40	.....	5.30	6.50	4.30	4.10	4.00	4.10	4.50	4.40	4.30
28	.....	.....	.....	5.40	6.40	4.30	4.10	4.00	4.20	4.50	4.40	4.30
29	.....	.....	.....	5.50	6.40	4.30	4.10	4.00	4.20	4.50	4.40	4.30
30	4.30	.....	.....	5.60	6.10	4.30	4.10	4.00	4.40	4.50	4.40	4.30
31	.....	.....	.....	.....	6.00	.....	4.10	4.00	.....	4.50	.....	4.30

GENEVA STATION ON UTAH LAKE.

This station, described in the Eighteenth Annual Report, Part IV, page 327, is located at Geneva, Utah, 3 miles south of American Fork, at the lower end of the lake. The gage consists of a vertical rod driven into the sand at the southern end of a bath-house, and nailed firmly to the floor of the house. The bench mark of the lake commissioners, a sandstone monument at the edge of the bluff and opposite the south end of the pavilion, is 18.644 feet above gage datum, which was placed 4 feet below "compromise point." The observer is John Dallin; post-office address, Pleasant Grove, Utah.

Daily gage height, in feet, of Utah Lake at Geneva, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.35	.....	1.90	1.80	.....	2.80	2.00	.....	0.80	.....	0.55	0.70
2	.....	1.56	.....	.....	.....	.....	.....	1.40	.....	.....	.....	.....
3	.....	.....	1.90	1.80	2.05	2.45	2.00	.....	.80	.....	.55	.....
4	1.35	1.58	.....	.....	.....	.....	.....	1.40	.75	0.40	.....	.75
5	.....	.....	.....	1.85	2.30	2.70	2.00	.....	.....	.....	.....	.....
6	1.40	1.68	.....	.....	.....	.....	.....	.....	.75	.40	.60	.80
7	.....	.....	.....	1.90	.....	2.70	1.90	1.30	.....	.35	.....	.....
8	1.40	1.40	.....	.....	2.40	.....	.....	.....	.70	.....	.60	.85
9	1.40	.....	.....	1.90	.....	.....	.....	1.30	.....	.40	.....	.....
10	.....	1.40	.....	.....	2.50	2.65	1.90	.....	.....	.....	.60	.....
11	1.40	.....	.....	.....	.....	.....	.....	.....	.60	.40	.....	.90
12	.....	1.40	.....	1.90	2.55	2.65	1.80	1.30	.....	.....	.....	.....
13	1.40	.....	.....	.....	.....	.....	.....	.....	.55	.35	.60	.90
14	.....	.....	.....	1.90	.....	2.40	1.75	1.20	.....	.....	.....	.....
15	1.40	1.40	.....	.....	2.60	.....	.....	.....	.50	.....	.55	.....
16	1.40	.....	.....	1.90	.....	2.40	.....	1.15	.....	.40	.....	.90
17	.....	1.45	.....	1.95	2.65	.....	1.70	.....	.....	.....	.....	.....
18	1.40	.....	.....	.....	.....	2.50	.....	1.10	.50	.45	.55	.90
19	.....	1.80	.....	2.00	2.40	.....	1.65	.....	.....	.....	.....	.....
20	1.42	1.85	.....	.....	.....	.....	.....	1.10	.50	.50	.60	.90
21	.....	.....	.....	2.00	.....	2.40	1.65	1.00	.....	.....	.....	.....
22	1.45	1.82	.....	.....	2.45	.....	.....	.....	.....	.....	.60	.95
23	1.45	.....	.....	.....	.....	2.40	.....	1.00	.40	.55	.....	.....
24	.....	1.82	.....	2.10	2.80	.....	1.55	.....	.....	.....	.....	.95
25	1.45	.....	1.70	.....	.....	.....	.....	.95	.40	.50	.....	.....
26	.....	1.88	.....	2.10	2.80	2.35	1.55	.....	.....	.....	.65	.....
27	1.45	1.88	1.75	.....	.....	.....	.....	.....	.40	.50	.70	.95
28	.....	.....	.....	2.15	.....	2.35	1.50	.90	.....	.....	.....	.....
29	.....	.....	1.80	.....	2.80	.....	.....	.....	.40	.50	.70	.95
30	1.50	.....	.....	2.20	.....	2.20	.....	.....	.40	.....	.....	1.00
31	.....	.....	1.80	.....	.....	.....	1.40	.....	.....	.....	.....	.....

POCATELLO STATION ON PORTNEUF RIVER.

This station is located at the wagon bridge, one-eighth of a mile below plant of the Pocatello Electric Power Company at Pocatello, Idaho. It was established May 18, 1897, by G. H. Nickerson. The rod is vertical and securely spiked to center pier of bridge. The bench mark is a spike driven into the end of a log in the east abutment of bridge and is opposite the 13-foot mark. The channel above the station is curved, while below it is straight. The right bank is high, but the left is liable to overflow at a 12-foot gage height. The bed of the stream is rocky. The current is sluggish at low stages. The observer is John A. Lillibridge, engineer at the power-house. The following discharge measurements were made by G. H. Nickerson and F. J. Mills in 1897:

May 20, gage height, 12.70 feet; discharge, 1,847 second-feet.
July 29, gage height, 6.95 feet; discharge, 123 second-feet.

Daily gage height, in feet, of Portneuf River at Pocatello, Idaho, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1	.....	10.70	7.80	6.90	6.80	17	.....	8.20	7.40	6.80	7.00
2	.....	10.60	7.70	6.90	6.80	18	12.80	8.00	7.50	6.80	7.00
3	.....	10.50	7.80	6.90	6.80	19	12.70	8.00	7.30	7.10	7.00
4	.....	10.30	7.70	6.90	7.00	20	12.70	8.00	7.30	7.00	7.00
5	.....	10.10	7.70	6.90	7.10	21	12.70	8.00	7.20	7.00	6.90
6	.....	9.80	7.70	6.90	7.10	22	12.70	7.90	7.20	7.00	6.90
7	.....	9.70	7.90	6.90	7.10	23	12.70	8.00	7.00	6.90	6.90
8	.....	9.50	7.80	6.80	7.00	24	12.50	8.10	7.00	6.90	7.00
9	.....	9.30	7.70	7.00	6.90	25	12.40	8.00	7.00	6.60	7.00
10	.....	9.30	7.50	6.90	7.10	26	12.20	8.00	7.00	6.70	7.00
11	.....	9.10	7.50	6.90	7.00	27	11.90	8.00	6.90	6.80	7.00
12	.....	9.00	7.50	6.90	7.00	28	11.60	8.00	7.00	6.80	7.10
13	.....	8.90	7.40	6.90	7.00	29	11.40	8.00	6.90	6.80	7.10
14	.....	8.80	7.40	6.90	7.00	30	11.20	7.90	6.90	6.80	7.20
15	.....	8.60	7.40	6.90	7.00	31	10.90	.....	6.90	6.80	.....
16	.....	8.40	7.40	6.80	7.00						

MONTGOMERY STATION ON SNAKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 334, is located at Montgomerys Ferry, 12 miles from Minidoka, Idaho, from which it is reached by stage. The gage is inclined and fastened to posts set in the ground. The bench mark is the head of a spike in the east post of the tool house, 1.2 feet above the ground and 52 feet west of the gage. Its elevation is 17.50 feet above datum. The letters "B. M." are marked in black paint on the post. The river is 800 feet wide at the section, with a hard gravel bottom. The observer is George Montgomery, the ferryman. The following are the discharge measurements as made from the ferryboat in 1897 by Cyrus C. Babb and G. H. Nickerson:

April 29, gage height, 4.63 feet; discharge, 9,473 second-feet.
June 8, gage height, 9.90 feet; discharge, 36,276 second-feet.

Daily gage height, in feet, of Snake River at Montgomerys Ferry, Idaho, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	5.15	12.15	6.00	3.25	2.60	17	3.20	9.75	8.90	4.70	2.80	2.70
2	.....	5.45	12.05	5.90	3.20	2.60	18	3.30	10.20	8.85	4.60	2.70	2.70
3	.....	5.70	12.00	5.80	3.20	2.60	19	3.45	10.45	8.75	4.50	2.70	2.70
4	.....	6.05	12.15	5.80	3.20	2.50	20	3.75	10.65	8.60	4.45	2.70	2.70
5	.....	6.45	12.10	5.90	3.20	2.60	21	3.95	10.85	8.15	4.35	2.70	2.70
6	.....	7.20	11.60	6.05	3.10	2.60	22	4.30	11.05	7.65	4.25	2.70	2.70
7	.....	7.75	10.80	6.15	3.00	2.70	23	4.55	11.45	7.25	4.15	2.70	2.70
8	.....	8.25	9.95	5.95	3.00	2.80	24	4.60	11.85	7.05	4.00	2.70	2.70
9	.....	8.80	9.40	5.65	3.00	2.70	25	4.45	12.10	6.85	3.85	2.70	2.70
10	.....	9.15	9.15	5.45	3.00	2.70	26	4.30	12.25	6.70	3.75	2.65	2.70
11	.....	9.15	9.35	5.30	2.90	2.70	27	4.20	12.45	6.55	3.70	2.60	2.70
12	.....	8.85	9.50	5.15	2.90	2.70	28	4.30	12.55	6.35	3.65	2.60	2.70
13	.....	8.75	9.35	5.05	2.90	2.70	29	4.60	12.60	6.15	3.60	2.60	2.70
14	.....	8.95	9.05	4.95	2.80	2.70	30	4.95	12.60	6.10	3.50	2.60	2.75
15	3.10	9.15	8.90	4.80	2.80	2.70	31	.....	12.35	.....	3.40	2.60	.....
16	3.20	9.35	8.90	4.70	2.80	2.70							

TOPONIS STATION ON MALAD AND LITTLE WOOD RIVERS.

This station, described in the Eighteenth Annual Report, Part IV, page 336, was established on June 2, 1896, on Malad and Little Wood rivers, at the wagon bridges near the railroad station of Toponis, Idaho. On the Malad River the rod of the wire gage is fastened to the stringer of the bridge, upper side. The 5-foot mark is opposite the center vertical. The distance from the end of the weight to the index marker is 13.60 feet. The outside edge of the pulley wheel is 1 foot from the zero of the rod. The bed of the river is of gravel, and not liable to change. During low stages the water is confined under the south span, but in floods it is under the two spans. The banks are not subject to overflow. The bridge over the Malad is one-half mile north of railroad station.

On the Little Wood River the station is one-half mile south of the railroad. The rod is fastened to the floor of the bridge, the 1.8-foot mark being opposite the iron vertical on the upper side of the bridge. The distance from the end of the weight to the index marker is 10.37 feet. The distance from the end of the rod to the outside edge of the pulley wheel is 1.97 feet. The channel is good and not obstructed by piers, but the banks overflow during flood stages. The observer is Will Hickman. The following discharge measurements were made by G. H. Nickerson and F. J. Mills in 1897:

Malad River:

May 21, gage height, 7.50 feet; discharge, 4,437 second-feet.
July 31, gage height, 2.80 feet; discharge, 81 second-feet.

Little Wood River:

May 21, gage height, 7.30 feet; discharge, 487 second-feet.

Daily gage height, in feet, of Malad River at Toponis, Idaho, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	2.80	.....	2.40	17	4.00	3.30	2.60	2.00	.....
2	.....	.....	2.80	.....	2.50	18	3.80	3.40	2.50	2.10	.....
3	.....	.....	2.80	.....	.....	19	3.50	3.30	2.50	2.30	.....
4	.....	4.00	2.80	.....	.....	20	.....	3.20	2.50	2.30	.....
5	.....	4.20	2.80	.....	.....	21	.....	3.30	2.50	2.30	.....
6	5.60	4.30	2.70	.....	.....	22	.....	3.30	2.40	2.20	.....
7	5.60	4.10	2.70	.....	.....	23	.....	3.20	2.30	2.30	.....
8	5.60	3.90	2.60	.....	.....	24	.....	3.30	2.20	2.20	.....
9	5.50	3.70	2.60	.....	.....	25	.....	3.20	2.00	2.40	.....
10	5.20	3.50	2.60	.....	.....	26	.....	3.00	2.00	2.40	.....
11	5.00	3.50	2.60	.....	.....	27	.....	3.00	2.00	2.40	.....
12	4.90	3.50	2.50	.....	.....	28	.....	2.90	2.00	2.50	.....
13	4.50	3.50	2.50	.....	.....	29	.....	2.90	.....	2.50	.....
14	4.20	3.40	2.40	.....	.....	30	.....	2.90	.....	2.40	.....
15	4.40	3.30	2.60	.....	.....	31	.....	2.80	.....	.....	.....
16	4.20	3.30	2.50	.....	.....						

Daily gage height, in feet, of Little Wood River at Toponis, Idaho, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.30	1.20	2.60	3.70	17	4.80	1.30	1.20	2.90	.....
2	.....	2.20	1.10	2.30	3.80	18	3.60	1.10	1.20	3.00	.....
3	.....	2.40	1.00	2.40	.....	19	3.30	1.20	1.40	3.10	.....
4	.....	2.20	1.00	2.40	.....	20	3.20	1.30	1.40	3.00	.....
5	.....	2.00	1.00	2.30	.....	21	3.00	1.20	1.40	3.20	.....
6	6.50	1.90	1.00	2.20	.....	22	3.40	1.20	1.40	3.30	.....
7	6.50	1.90	1.00	2.20	.....	23	3.70	1.20	1.30	3.30	.....
8	5.50	1.70	1.00	2.30	.....	24	3.90	1.10	1.40	3.30	.....
9	4.80	1.50	1.20	2.40	.....	25	4.00	1.30	1.50	3.40	.....
10	4.60	1.30	1.20	2.50	.....	26	4.10	1.20	2.00	3.40	.....
11	4.20	1.20	1.30	2.60	.....	27	4.20	1.20	2.00	3.50	.....
12	4.00	1.20	1.20	2.60	.....	28	4.40	1.20	2.20	3.40	.....
13	4.00	1.10	1.20	2.70	.....	29	3.50	1.20	2.80	3.50	.....
14	3.80	1.10	1.10	2.80	.....	30	3.50	1.20	2.90	3.60	.....
15	4.20	1.00	1.30	2.90	.....	31	.....	1.30	2.80	.....	.....
16	4.00	1.00	1.30	2.90	.....						

GRANDVIEW STATION ON BRUNEAU RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 339. The point of measurement is 10 miles east of Grandview, Idaho, below the head of the Bruneau ditch. Observations of gage height are regularly kept, and estimates of discharge are made from them by A. J. Wiley, chief engineer of the Owyhee Land and Irrigation Company. C. C. Gregg is the observer.

Daily gage height, in feet, of Bruneau River at Grandview, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.65	1.70	2.30	4.80	4.45	2.40	1.40	1.15	1.30	1.60	1.75
2	1.60	1.65	1.70	2.25	4.75	4.20	2.40	1.40	1.15	1.30	1.65	1.70
3	1.55	1.65	1.70	2.30	4.90	4.00	2.40	1.50	1.15	1.30	1.70	1.70
4	1.55	1.65	1.70	2.25	5.00	3.65	2.35	1.50	1.15	1.35	1.65	1.65
5	1.55	1.70	1.70	2.65	5.10	3.60	2.35	1.40	1.15	1.35	1.60	1.65
6	1.55	1.95	1.70	3.50	5.30	3.50	2.30	1.35	1.15	1.35	1.60	1.65
7	1.60	2.70	1.75	3.75	5.50	3.40	2.20	1.35	1.15	1.40	1.70	1.75
8	1.55	2.20	1.75	3.45	5.60	3.50	2.15	1.30	1.15	1.40	1.65	1.80
9	1.55	2.05	1.70	3.10	5.25	3.45	2.15	1.30	1.20	1.40	1.65	1.80
10	1.55	1.95	1.65	3.60	4.70	3.60	2.10	1.30	1.20	1.50	1.60	1.75
11	1.50	1.80	1.65	4.40	4.50	3.45	2.10	1.30	1.20	1.55	1.65	1.80
12	1.50	1.80	1.65	5.00	4.45	3.35	2.00	1.30	1.20	1.55	1.70	1.80
13	1.50	1.80	1.60	4.50	4.35	3.30	1.95	1.30	1.20	1.60	1.70	1.80
14	1.60	1.70	1.50	4.60	4.40	3.30	2.00	1.30	1.20	1.55	1.70	1.85
15	1.60	1.60	1.55	4.60	4.55	3.30	2.00	1.35	1.25	1.60	1.70	1.85
16	1.60	1.80	1.60	4.65	4.60	3.25	2.00	1.25	1.25	1.60	1.70	1.80
17	1.60	1.70	1.65	4.80	4.65	3.15	1.95	1.25	1.25	1.65	1.70	1.70
18	1.60	1.65	1.65	5.10	4.80	3.10	1.90	1.25	1.25	1.65	1.70	1.75
19	1.50	1.65	1.65	5.50	5.00	3.00	1.90	1.25	1.30	1.60	1.70	1.70
20	1.50	1.65	1.65	6.00	5.15	2.90	1.90	1.25	1.30	1.60	1.75	1.80
21	1.60	1.65	1.65	5.75	5.35	2.80	1.85	1.05	1.30	1.60	1.75	1.70
22	1.70	1.65	1.60	5.15	5.65	2.65	1.80	1.10	1.30	1.60	1.75	1.75
23	1.70	1.70	1.60	4.56	5.50	2.60	1.65	1.10	1.30	1.60	1.85	1.70
24	1.65	1.65	1.60	4.00	5.65	2.60	1.60	1.10	1.30	1.65	1.85	1.70
25	1.65	1.65	1.65	3.70	5.45	2.60	1.60	1.10	1.30	1.65	1.80	1.70
26	1.60	1.65	7.00	3.80	5.10	2.50	1.65	1.10	1.30	1.65	1.80	1.75
27	1.60	1.65	7.00	4.00	4.70	2.50	1.55	1.15	1.30	1.65	1.75	1.70
28	1.50	1.65	4.00	4.60	5.10	2.50	1.50	1.10	1.30	1.65	1.70	1.80
29	1.55	.....	3.60	4.80	4.70	2.55	1.45	1.15	1.30	1.65	1.65	1.75
30	1.60	.....	2.80	5.00	4.50	2.20	1.45	1.15	1.30	1.65	1.70	1.70
31	1.70	.....	2.55	.....	4.50	.....	1.45	1.15	.....	1.65	.....	1.70

BOISE STATION ON BOISE RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 340, is located about 9 miles above Boise, Idaho, at the mouth of the canyon. April 18 the river cut into the right bank of the station, carrying out the cable and leaving the gage on a small island, so that the record after that date is unreliable. A temporary gage was therefore established May 12 at the Broadway Bridge, at Boise, and a record kept by it until June 17, when a new gage was again placed in the canyon 1 mile above the old location. The inclined rod is firmly attached to a cottonwood tree. The bench mark is a 20-penny spike in the upstream face of the 6 by 8 cable support, about 2 feet above the ground. Its elevation is 15.00 feet above datum; also two spikes in same post are 14.00 feet above datum. Discharge measurements are made from a cable and car, 50 feet below the gage. An auxiliary cable for flood measurements is placed 117 feet above the main cable. The observer is Mrs. Ed. Marnell. The following are the discharge measurements made on the Boise River by F. J. Mills and others in 1897:

April 21, at Star bridge, discharge, 24,312 second-feet.
May 18, at Broadway bridge, gage height, 4.30 feet; discharge, 23,522 second-feet.
June 29, gage height, 3.25 feet; discharge, 3,526 second-feet.
August 6, gage height, 1.60 feet; discharge, 1,357 second-feet.
September 18, gage height, 1.30 feet; discharge, 987 second-feet.
October 25, gage height, 1.50 feet; discharge, 1,256 second-feet.

Daily gage height, in feet, of Boise River at Boise, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.00	1.90	1.70	3.60	7.30	.....	3.20	1.60	1.20	1.20	1.35
2	1.90	1.80	1.70	3.30	8.00	.....	3.60	1.60	1.30	1.25	.....
3	1.90	1.60	1.90	3.20	8.20	.....	3.30	1.50	1.30	1.25	.....
4	1.80	1.60	2.00	3.30	8.00	.....	3.05	1.55	1.30	1.25	1.30
5	1.80	1.90	2.00	3.20	8.00	.....	3.05	1.55	1.40	1.25	.....
6	1.70	2.00	1.96	3.50	7.50	.....	2.90	1.55	1.40	1.25	.....
7	1.70	1.90	2.00	3.50	7.00	.....	2.75	1.55	1.40	1.30	.....
8	1.80	2.40	2.10	3.40	7.00	.....	2.70	1.50	1.30	1.25	1.30
9	1.80	2.40	2.00	3.90	.....	.....	2.40	1.50	1.30	1.25	.....
10	1.90	2.20	1.90	4.30	.....	.....	2.30	1.45	1.40	1.30	.....
11	1.70	2.10	1.90	5.00	.....	.....	2.35	1.45	1.40	1.35	1.35
12	1.60	2.10	1.70	5.60	.....	.....	2.35	1.45	1.40	1.40	.....
13	1.40	2.00	1.50	6.00	.....	.....	2.30	1.40	1.50	1.40	.....
14	1.20	2.00	1.70	6.20	.....	.....	2.30	1.40	1.50	1.35	.....
15	1.20	2.00	1.70	7.30	.....	.....	2.30	1.40	1.40	1.35	1.30
16	1.20	1.90	1.70	8.00	.....	.....	2.20	1.35	1.40	1.35	.....
17	1.10	1.90	2.00	8.90	.....	4.00	2.20	1.30	1.40	1.30	.....
18	1.10	1.80	2.00	9.00	.....	3.80	2.30	1.30	1.30	1.30	1.50
19	1.10	1.80	1.90	9.30	.....	3.50	2.20	1.25	1.30	1.35	.....
20	1.40	1.70	1.80	8.90	.....	3.50	2.00	1.25	1.30	1.25	.....
21	1.60	1.60	1.80	6.80	.....	3.40	1.95	1.20	1.40	1.30	.....
22	1.60	1.70	1.90	6.70	.....	3.50	1.80	1.15	1.40	1.30	1.40
23	1.80	1.70	2.20	6.60	.....	3.80	2.00	1.20	1.40	1.30	.....
24	1.50	1.70	2.60	6.70	.....	3.40	1.95	1.20	1.40	1.40	.....
25	1.40	1.60	3.00	6.90	.....	3.30	1.90	1.20	1.40	1.50	1.50
26	1.40	1.50	4.00	7.40	.....	3.30	1.80	1.30	1.20	1.50	.....
27	1.20	1.50	4.20	7.40	.....	3.40	1.80	1.30	1.20	1.40	.....
28	1.20	1.60	4.00	7.50	.....	3.30	1.75	1.30	1.20	1.35	.....
29	1.60	.....	3.90	7.00	.....	3.20	1.70	1.30	1.20	1.35	1.30
30	1.80	.....	3.70	6.50	.....	3.20	1.60	1.30	1.20	1.35	.....
31	1.90	.....	3.50	.....	.....	.....	1.65	1.20	.....	.....	.....

VALE STATION ON MALHEUR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 345, is located at the iron highway bridge at Vale, Oregon. The observer is E. R. Murray, postmaster. The station is distant from the observer's house about one-fourth of a mile. The gage is inclined, and is in two parts. The lower part is graduated from 1.6 to 9.1 feet, the distance between the footmarks being 1.95 feet. The upper part is graduated from 9.1 to 11.7 feet, the distance between the footmarks being 3 feet. The channel is composed of earth and sand and is shifting. The bench mark is on a flat rock, nearly buried, above the right bank of the river, 50 feet southeast of south abutment of new bridge, and is 12.32 feet above the zero of the gage. Measurements are made from the iron highway bridge. The following discharge measurements were made in 1897 by Frank Shirley and G. H. Nickerson:

April 17, gage height, 7.15 feet; discharge, 4,857 second-feet.
May 15, gage height, 4.75 feet; discharge, 1,883 second-feet.
May 28, gage height, 4.37 feet; discharge, 1,694 second-feet.

Daily gage height, in feet, of Malheur River at Vale, Oregon, for 1897.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	6.10	3.75	2.43	12	.....	5.05	2.65	2.10	23	7.70	4.50	2.40	1.45
2	.....	6.10	3.55	2.40	13	.....	4.95	2.55	2.00	24	7.20	4.45	2.40	1.40
3	.....	6.10	3.45	2.40	14	.....	4.80	2.50	1.98	25	6.60	4.40	2.38	1.40
4	.....	5.95	3.25	2.35	15	6.55	4.70	2.50	1.90	26	6.45	4.35	2.85	1.40
5	.....	5.95	3.10	2.30	16	6.75	4.70	2.50	1.90	27	6.65	4.35	2.68	1.38
6	.....	5.90	3.20	2.30	17	7.25	4.80	2.45	1.87	28	7.00	4.35	2.65	1.33
7	.....	6.05	3.05	2.28	18	8.30	5.00	2.40	1.75	29	7.10	4.15	2.60	1.30
8	.....	6.10	3.00	2.20	19	8.95	4.90	2.40	1.65	30	6.60	3.95	2.55	1.25
9	.....	5.80	2.90	2.20	20	9.30	4.90	2.50	1.55	31	.....	3.80	.....	1.20
10	.....	5.40	2.95	2.18	21	10.10	4.85	2.43	1.50					
11	.....	5.15	2.75	2.13	22	8.50	4.60	2.40	1.50					

PAYETTE STATION ON PAYETTE RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 350, is located at the highway bridge at Payette, Idaho. The observer is J. A. Ballinger, the town marshal at Payette. The station is distant from the observer's house about one-half mile. The gage is vertical, of pine plank, spiked to a wooden pier, graduated from 0 to 12.5 feet. It is easily read from the bridge. The character of the channel is sandy and shifting. The point 12.5 on the gage is level with the top of the pier, on which is the mark "B. M." Measurements of discharge were made as follows by G. H. Nickerson in 1897:

May 14, gage height, 7.40 feet; discharge, 19,422 second-feet.
May 27, gage height, 8.20 feet; discharge, 26,707 second-feet.

Daily gage height, in feet, of Payette River at Payette, Idaho, for 1897.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	.....	7.50	3.80	12	.....	5.30	2.80	23	8.50	4.10	1.90
2	.....	7.00	3.90	13	.....	5.30	2.70	24	8.40	4.00	1.90
3	.....	6.80	3.90	14	7.40	5.30	2.60	25	8.50	4.00	1.80
4	.....	6.10	3.90	15	7.60	5.20	2.50	26	8.60	3.90	1.80
5	.....	5.90	3.70	16	7.80	5.00	2.40	27	8.20	3.80	1.70
6	.....	6.10	3.60	17	8.00	4.90	2.30	28	7.90	3.80	1.70
7	.....	5.90	3.50	18	8.30	4.70	2.20	29	7.80	3.80	1.60
8	.....	5.60	3.30	19	8.40	4.60	2.20	30	7.80	3.90	1.60
9	.....	5.60	3.20	20	8.60	4.40	2.10	31	7.60	.....	1.50
10	.....	5.50	3.00	21	8.70	4.30	2.10				
11	.....	5.40	2.90	22	8.50	4.20	2.00				

WEISER STATION ON WEISER RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 352, is about 10 miles above the town of Weiser, Idaho, at the mouth of the canyon. The gage is firmly fastened to posts driven into the ground. The 6-foot mark is 13.46 feet below a bench mark on a large bowlder 30 feet south of the gage. The observer is J. W. Lane, whose house is about one-fourth of a mile from the gage. The channel is straight for some distance above and below the section, the banks are high, and the bed is gravelly. The following discharge measurements were made in 1897 by F. J. Mills, Cyrus C. Babb, and others:

May 26, gage height, 4.95 feet; discharge, 5,026 second-feet.
August 5, gage height, 0.70 foot; discharge, 100 second-feet.
October 23, gage height, 0.95 foot; discharge, 153 second-feet.

Daily gage height, in feet, of Weiser River at Weiser, Idaho, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	5.10	5.60	3.70	1.80	0.80	0.70	17.....	7.10	6.00	2.30	1.30	0.60	0.80
2....	5.85	5.80	3.40	1.80	.80	.70	18.....	7.50	6.00	2.30	1.20	.60	.80
3....	6.00	5.90	3.20	2.00	.80	.70	19.....	7.90	5.90	2.20	1.20	.60	.80
4....	6.10	6.00	3.10	1.90	.70	.70	20.....	8.30	5.90	2.10	1.20	.60	.80
5....	7.00	6.20	3.00	1.80	.70	.70	21.....	7.90	5.90	2.10	1.20	.60	.80
6....	6.90	6.40	3.00	1.70	.70	.70	22	7.60	5.80	2.00	1.10	.60	.80
7....	6.70	6.90	2.90	1.70	.70	.70	23.....	7.30	5.50	2.00	1.10	.60	.80
8....	6.50	6.40	2.90	1.70	.60	.80	24.....	5.70	5.00	2.00	1.10	.60	.90
9....	6.90	5.80	2.80	1.60	.60	.80	25.....	5.60	5.20	1.90	1.00	.60	.90
10....	7.00	5.40	2.70	1.60	.60	.80	26.....	6.00	5.00	1.90	1.00	.60	.90
11....	7.00	5.40	2.60	1.50	.60	.80	27.....	6.50	4.30	2.10	1.00	.60	.90
12....	6.50	5.40	2.60	1.50	.60	.80	28.....	6.90	4.20	2.00	1.00	.60	.90
13....	6.60	5.50	2.50	1.40	.60	.80	29.....	6.50	4.10	1.90	.90	.60	.90
14....	6.60	5.70	2.50	1.40	.60	.80	30.....	5.80	4.00	1.80	.90	.60	.90
15....	6.50	5.90	2.40	1.30	.60	.80	31.....	.....	4.00	.....	.90	.60	.....
16....	6.70	6.00	2.40	1.30	.60	.80							

HOOPER STATION ON PALOUSE RIVER.

This station is located on the Palouse River at Hooper, Washington. It was established April 1, 1897, by the land department of the Northern Pacific Railroad. September 9, 1897, this Survey took charge of the station, placing the gage rod 1 mile below the former location and opposite the water tank, and stretching a cable across the river for discharge measurements. The rod is inclined, fastened to posts driven into the right bank. The bench mark is a point of rock, marked with red paint, on a ledge on the left bank of the river opposite the gage, and its elevation is 7.60 feet above datum. When the new gage reads 2.1 feet the height on the Northern Pacific Railroad gage is 6.1 feet. The channel is gravelly and not liable to change. The left bank is high and can not overflow. The right bank overflows in extreme high water. The initial point for sounding is the cable post on left bank. The station is about 3 miles above the mouth of Cow Creek and 2 miles below the head of the ditch of the Palouse Irrigation Company, carrying 25 second-feet when full The observer is Frank Hill, rancher. Discharge measurements were made by Cyrus C. Babb in 1897, as follows:

September 9, gage height, 2.10 feet; discharge 73 second-feet.
October 1, gage height, 1.90 feet; discharge, 50 second-feet.

Daily gage height, in feet, of Palouse River at Hooper, Washington, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.10	8.45	6.08	6.42	5.55	.....	1.90	2.00	3.20
2	9.85	8.20	6.08	5.42	5.52	.....	1.90	2.00	3.30
3	10.18	8.10	6.03	6.42	5.62	.....	1.95	2.05	3.60
4	10.11	8.12	6.01	6.42	5.68	.....	2.00	2.05	3.70
5	9.98	8.00	5.95	6.50	5.65	.....	2.00	2.05	3.60
6	9.98	7.98	5.94	6.50	5.65	.....	1.95	2.05	3.60
7	9.97	7.98	5.93	6.45	5.72	.....	1.95	2.20	5.00
8	10.22	8.12	6.02	6.36	5.82	.....	1.90	2.20	5.95
9	10.08	8.00	6.21	6.31	5.85	2.10	1.90	2.10	7.00
10	9.90	7.90	6.20	6.25	5.85	2.20	1.95	2.20	7.05
11	9.80	7.66	6.15	6.20	5.92	2.10	2.00	2.25	6.90
12	10.15	7.44	6.07	6.15	5.88	2.10	2.00	2.30	6.30
13	10.58	7.40	6.07	6.46	5.80	2.20	1.95	2.50	6.60
14	10.15	7.20	6.07	6.39	5.80	2.20	1.90	2.70	6.50
15	9.80	7.05	6.10	6.31	5.80	2.10	1.90	3.50	7.55
16	9.97	7.05	6.10	6.22	5.80	2.10	1.90	3.90	7.00
17	10.04	7.05	6.18	6.18	5.78	2.00	1.95	3.60	6.30
18	10.17	7.11	6.28	6.12	5.77	2.00	1.95	3.40	5.40
19	10.25	7.00	6.55	6.05	5.95	2.00	1.95	3.40	5.20
20	10.30	6.89	7.20	6.02	5.97	2.00	2.00	3.60	4.90
21	10.24	6.78	7.50	5.99	5.95	2.00	2.00	4.35	4.70
22	10.10	6.63	7.20	5.99	5.89	2.00	2.00	4.80	4.60
23	9.80	6.55	7.00	5.94	5.87	2.00	2.00	4.70	4.50
24	9.40	6.49	6.88	5.93	5.89	1.90	2.00	4.20	4.40
25	9.08	6.40	6.85	5.93	5.82	1.90	2.00	4.00	4.35
26	8.80	6.39	6.77	5.92	5.86	1.90	2.05	3.65	4.60
27	8.69	6.38	6.62	5.91	5.90	1.90	2.05	3.60	4.65
28	8.72	6.38	6.58	5.80	5.91	1.90	2.00	3.50	4.90
29	8.89	6.37	6.62	5.70	5.85	1.90	2.00	3.40	6.70
30	8.74	6.22	6.50	5.65	5.82	1.90	2.00	3.30	7.10
31	.....	6.13	.....	5.60	5.80	.....	2.00	.....	7.40

Readings on Northern Pacific Railroad gage April 1 to August 31. United States Geological Survey gage established September 9 and located 1 mile below Northern Pacific Railroad gage, and also made to read 4 feet lower.

SELAH STATION ON YAKIMA RIVER.

This station is located on the Yakima River at the Northern Pacific Railway bridge, or first crossing of the Yakima, 7 miles above the town of North Yakima, Washington. It was established by Cyrus C. Babb, May 19, 1897, after the Naches station had been discontinued, with the idea that the difference in discharge between this station and the one at Union Gap would give approximately the discharge of the Natches River. The gage is the wire type, the rod being fastened to the guard rail of the bridge, west span, lower side. The length of gage wire is 39 feet. The pulley distance is 2 feet. The bench mark is the top of the north sill of the clearance posts, about 150 feet west of the bridge, and its elevation is 35.21 feet above gage datum. During the months of September and October the bridge was undergoing repairs, and gage records could not be kept. The observer is Pat Gallagher, section foreman. The following measurements were made in 1897 by Cyrus C. Babb:

May 19, gage height, 10.77 feet; discharge, 13,904 second-feet.
May 26, gage height, 8.88 feet; discharge, 7,424 second-feet.
June 10, gage height, 7.60 feet; discharge, 4,859 second-feet.
June 18, gage height, 6.90 feet; discharge, 3,185 second-feet.
July 3, gage height, 7.10 feet; discharge, 3,636 second-feet.
July 10, gage height, 6.28 feet; discharge, 2,300 second-feet.
July 17, gage height, 5.81 feet; discharge, 1,751 second-feet.
July 29, gage height, 5.15 feet; discharge, 1,019 second-feet.
August 13, gage height, 4.91 feet; discharge, 810 second-feet.

Daily gage height, in feet, of Yakima River at Selah, Washington, for 1897.

Day.	May.	June.	July.	Aug.	Oct.	Nov.	Dec.
1	.....	8.40	6.90	.....	.....	4.90	6.20
2	.....	8.20	6.90	5.00	.....	4.90	6.20
3	.....	8.10	7.20	5.00	.....	4.90	6.20
4	.....	7.80	.....	5.00	.....	4.90	6.20
5	.....	7.60	7.10	4.90	.....	4.90	.....
6	.....	.....	6.90	4.90	.....	4.90	6.20
7	.....	7.50	6.80	4.90	.....	.....	6.20
8	.....	7.70	6.60	.....	.....	4.90	6.60
9	.....	7.80	6.50	4.90	.....	4.90	6.80
10	.....	7.50	6.80	4.90	.....	4.90	6.80
11	.....	7.30	.....	4.90	.....	5.70	6.80
12	.....	7.20	6.10	4.90	.....	6.50	.....
13	.....	.....	6.10	4.80	.....	7.60	6.80
14	.....	7.20	6.10	4.80	.....	.....	6.40
15	.....	7.20	6.00	.....	.....	7.30	6.40
16	.....	7.00	5.90	4.80	.....	7.00	6.30
17	.....	7.00	5.90	4.80	.....	6.60	6.10
18	.....	7.00	.....	4.80	.....	7.00	6.10
19	10.80	6.90	5.80	4.70	.....	12.80	.....
20	10.60	6.80	5.70	4.70	4.90	11.60	6.00
21	10.40	6.70	5.60	4.70	4.90	.....	5.90
22	10.30	6.90	5.60	.....	4.90	9.10	5.90
23	.....	7.30	5.60	.....	4.90	8.40	5.70
24	9.70	7.30	5.60	.....	.....	7.90	5.60
25	9.20	7.20	.....	.....	4.90	7.40	5.60
26	8.90	7.20	5.40	.....	4.90	6.90	.....
27	8.70	.....	5.30	.....	4.90	6.30	5.60
28	8.50	7.10	5.30	.....	4.90	.....	6.00
29	8.30	7.00	5.20	.....	4.90	6.20	8.60
30	.....	6.90	5.10	.....	4.90	6.20	9.20
31	8.30	.....	5.10	.....	.....	.....	8.80

NORTH YAKIMA STATION ON NACHES RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 355, is located at the highway bridge, 2 miles from North Yakima, Washington, at the mouth of the river. The rod, a 2 by 6 inch timber, is fastened to the crib bulwark, just below the highway bridge. The flood of November, 1896, modified the channel very greatly, depositing a large mass of coarse gravel and small bowlders along the right side of the channel at the section, so that the rod was 50 feet, more or less, from the edge of the water at low stages. The current is swift, even at low water. On account of the instability of the channel the station was abandoned in February, 1897, although a number of discharge measurements were made during the season. The station was located below the heads of a number of ditches. May 19, 1897, a station was established on the Yakima River, 5 miles above the mouth of the Naches, at the Northern Pacific Railway bridge near Selah, Washington, with the idea that the difference in discharge between this station and the one at Union Gap would give approximately the discharge of the Naches River. Two ditches, those of the Moxee Valley, are taken out between the two points, but their amount is about counterbalanced by that received from Ahtanum Creek and the wastage at Old Town. The following discharge measurements were made in 1897 by Cyrus C. Babb and Sydney Arnold:

June 10, discharge, 3,178 second-feet.
June 18, discharge, 1,993 second-feet.
July 29, discharge, 781 second-feet.
September 22, discharge, 385 second-feet.
November 15, discharge, 1,500 second-feet.

Daily gage height, in feet, of Naches River at North Yakima, Washington, for 1897.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	3.00	3.00	9	3.00	2.80	17	2.70	2.50	25	3.50	.....
2	3.00	3.00	10	2.90	2.70	18	2.70	2.50	26	3.40	.....
3	2.90	3.00	11	2.90	2.70	19	2.80	2.40	27	3.30	.....
4	2.90	2.90	12	2.90	2.70	20	3.10	2.40	28	3.20	.....
5	3.00	2.90	13	2.80	2.60	21	3.30	.....	29	3.10	.....
6	3.00	2.90	14	2.80	2.60	22	3.60	.....	30	3.10	.....
7	3.00	2.90	15	2.70	2.60	23	3.60	.....	31	3.10	.....
8	3.00	2.80	16	2.70	2.50	24	3.50	.....			

UNION GAP STATION ON YAKIMA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 356, is located at Union Gap, 6 miles below North Yakima, Washington, and 1,000 feet below the highway bridge. The gage rod is inclined and is attached to a willow stump and to posts set into the ground and loaded with rock. The bench mark is a stone, marked "B. M.," 39 feet west of the gage and 8.5 feet east of the railroad track. It is 29.85 feet above gage datum. The gaging cable and car is about 50 yards above the rod. The channel of the river is straight for several hundred feet, both above and below the cable. During floods a portion of the water passes through a depression in the left bank, and this must be measured from the bridge. The right bank is high and will not overflow. The observer is Ed. Farmer, section foreman. The following measurements were made in 1897 by Cyrus C. Babb:

May 15, gage height, 10.90 feet; discharge, 19,234 second-feet.
May 25, gage height, 9.40 feet; discharge, 15,543 second-feet.
June 9, gage height, 8.15 feet; discharge, 8,938 second-feet.
June 16, gage height, 7.25 feet; discharge, 5,901 second-feet.
July 2, gage height, 7.35 feet; discharge, 6,275 second-feet.
July 9, gage height, 6.45 feet; discharge, 3,973 second-feet.
July 15, gage height, 6.05 feet; discharge, 3,097 second-feet.
July 23, gage height, 5.48 feet; discharge, 2,361 second-feet.
August 7, gage height, 4.80 feet; discharge, 1,314 second-feet.
September 6, gage height, 4.55 feet; discharge, 1,140 second-feet.
September 21, gage height, 4.26 feet; discharge, 683 second-feet.

Daily gage height, in feet, of Yakima River at Union Gap, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.60	.....	.....	6.80	9.00	8.70	7.20	4.90	4.40	4.30	4.40	6.30
2	.....	.....	.....	6.90	9.20	8.60	7.40	4.80	4.30	4.30	4.40	6.30
3	.....	.....	.....	6.80	9.40	8.50	7.35	4.80	4.30	4.30	4.40	6.20
4	.....	.....	.....	7.40	9.60	8.30	7.20	4.80	4.40	4.30	4.40	6.10
5	.....	.....	5.60	7.60	9.80	8.20	7.10	4.80	4.40	4.20	4.40	6.00
6	.....	.....	.....	7.90	9.60	8.10	6.90	4.80	4.40	4.20	4.40	6.80
7	.....	.....	.....	7.90	9.00	8.00	6.70	4.80	4.40	4.30	4.40	6.90
8	.....	.....	.....	7.90	9.00	8.30	6.60	4.80	4.40	4.20	4.40	7.10
9	.....	.....	.....	8.70	9.10	8.20	6.50	4.80	4.40	4.20	4.50	7.00
10	.....	.....	5.40	9.40	9.20	7.90	6.30	4.70	4.40	4.20	4.80	6.90
11	.....	.....	.....	8.40	9.20	7.80	6.30	4.70	4.40	3.20	5.60	6.80
12	.....	.....	.....	9.60	9.10	7.60	6.20	4.70	4.40	4.20	6.50	6.70
13	.....	.....	.....	9.60	9.40	7.70	6.10	4.70	4.30	4.20	7.20	6.70
14	.....	.....	5.20	10.00	9.90	7.50	6.00	4.70	4.30	4.20	7.00	6.60
15	5.40	5.50	5.10	10.60	10.00	7.40	6.00	.....	4.30	4.20	6.80	6.50
16	.....	.....	5.10	10.90	11.40	7.30	6.00	.....	4.30	4.20	5.90	6.40
17	.....	.....	5.10	11.40	11.40	7.20	5.90	.....	4.20	4.20	5.80	6.30
18	.....	.....	5.30	.....	11.40	7.20	5.80	.....	4.20	4.20	6.10	6.10
19	.....	.....	5.30	11.00	11.20	7.00	5.80	.....	4.30	4.20	11.00	6.10
20	.....	6.70	5.20	12.00	10.90	6.90	5.70	4.60	4.30	4.20	11.60	5.90
21	.....	.....	5.10	11.60	10.80	6.80	5.60	4.60	4.30	4.30	9.60	5.80
22	.....	.....	5.10	11.00	10.40	7.10	5.50	4.60	4.30	4.40	9.00	5.60
23	.....	.....	5.20	10.60	10.20	7.40	5.50	4.50	4.20	4.40	8.30	5.70
24	.....	.....	6.00	9.00	10.00	7.40	5.40	4.50	4.20	4.50	7.70	5.70
25	.....	.....	6.80	9.40	9.80	7.30	5.40	4.50	4.20	4.50	7.30	5.60
26	.....	6.00	6.40	9.60	9.60	7.20	5.30	4.50	4.30	4.50	6.90	5.60
27	.....	.....	6.20	9.80	9.40	7.10	5.30	4.50	4.20	4.40	6.70	5.70
28	.....	.....	6.40	9.70	9.20	7.30	5.20	4.40	4.20	4.40	6.60	5.70
29	.....	.....	6.80	9.40	9.10	7.20	5.10	4.40	4.20	4.50	6.60	5.70
30	.....	.....	6.60	9.10	9.00	7.10	5.10	4.40	4.30	4.50	6.30	8.80
31	.....	.....	6.60	.....	8.90	.....	5.10	4.40	.....	4.40	.....	8.20

KIONA STATION ON YAKIMA RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 358, is located at the highway bridge at Kiona, Washington. The rod of the wire gage is placed on the lower side of the bridge. The distance from the end of the weight to the index marker is 27.21 feet. From the end of the rod to the outside edge of the pulley wheel it is 2 feet. The section is an excellent one for measurements. The channel is straight for some distance above and below. The banks are medium high and the bed is composed of a firm gravel. The observer is W. A. Kelso. The following discharge measurements were made in 1897 by Cyrus C. Babb and Sydney Arnold:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
May 8....	11.50	16,557	June 15 ...	8.05	6,908	Aug. 5 ...	4.61	1,217
May 24...	11.52	16,344	July 7.....	7.15	5,118	Aug. 30..	4.10	762
May 29...	9.74	11,338	July 13....	6.30	3,475	Nov. 6 ...	4.08	839
June 8 ...	8.75	8,868	July 21....	5.55	2,318	Dec. 29 ..	8.54	7,459

Daily gage height, in feet, of Yakima River at Kiona, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.00	7.15	6.08	6.81	10.48	10.67	7.52	4.80	4.00	3.90	.....	6.53
2	6.87	.....	6.27	6.68	10.40	10.16	7.42	.....	4.05	.....	4.12	6.50
3	.....	6.94	6.31	6.69	10.36	9.60	7.80	4.70	4.10	3.90	4.10	.....
4	.....	.....	6.30	7.05	10.22	9.30	7.80	4.68	4.12	3.90	4.09	6.24
5	6.55	6.82	.....	7.16	10.34	8.84	7.64	4.61	4.16	3.87	4.08	6.15
6	6.45	6.88	.....	7.22	10.48	8.67	7.42	4.55	4.18	3.86	4.08	6.71
7	6.52	.....	.....	7.42	11.22	8.61	7.15	4.50	4.18	3.85	4.12	7.50
8	6.50	.....	.....	7.75	11.50	8.80	6.98	4.50	4.16	3.84	4.15	8.22
9	.....	.....	.....	7.69	11.34	8.90	6.85	4.48	4.10	3.80	4.18	8.21
10	6.54	6.41	.....	7.98	10.79	8.75	6.64	4.41	4.06	3.78	4.19	7.95
11	.....	6.38	5.85	9.14	10.42	8.42	6.35	4.40	4.00	3.78	4.21	7.82
12	.....	6.85	5.78	10.01	10.26	8.08	6.32	4.40	4.00	.....	4.44	7.77
13	6.44	6.84	5.56	10.04	10.54	8.15	6.30	4.38	3.98	3.76	5.85	7.70
14	.....	.....	5.66	10.17	11.14	8.12	6.25	4.38	3.97	3.76	7.51	7.50
15	.....	.....	5.71	10.62	11.92	8.05	6.07	4.35	3.95	3.76	7.42	7.55
16	6.13	6.95	5.68	11.18	12.56	7.78	6.00	4.28	3.90	3.77	6.60	7.50
17	.....	.....	5.70	11.74	12.85	7.58	5.85	4.27	3.94	3.80	6.48	7.30
18	6.04	.....	5.75	12.40	13.08	7.50	5.80	4.27	3.94	3.82	6.34	6.95
19	6.07	.....	5.80	13.17	13.30	7.41	5.76	4.23	3.91	3.85	8.97	6.68
20	6.00	6.50	5.80	13.92	13.14	7.25	5.58	4.20	3.89	3.88	11.67	6.40
21	.....	.....	5.72	14.42	12.81	7.10	5.54	4.20	3.90	3.90	12.50	6.30
22	6.78	.....	5.69	13.49	.....	7.11	5.50	4.22	3.90	3.98	11.66	6.15
23	8.82	.....	5.62	12.85	12.30	7.45	5.45	4.15	3.90	.....	10.82	6.10
24	.....	.....	.....	11.93	11.50	7.80	5.33	4.15	3.91	4.10	9.43	6.00
25	.....	.....	5.84	11.24	10.86	7.86	5.27	.....	3.94	4.16	8.38	5.95
26	8.15	.....	7.02	11.10	10.70	7.77	5.27	4.14	3.90	4.18	8.00	5.92
27	.....	6.00	7.76	11.32	10.50	7.62	5.16	4.14	3.83	4.17	7.58	5.90
28	.....	.....	7.42	11.50	10.00	7.60	5.07	4.10	3.83	4.17	7.02	6.00
29	7.55	.....	7.44	11.35	9.75	7.72	4.97	4.08	3.84	.....	6.95	7.90
30	7.50	.....	7.26	10.72	9.86	7.55	4.90	4.04	3.86	.....	6.63	10.39
31	7.35	.....	6.95	.....	10.60	.....	4.80	4.00	.....	.....	.....	10.55

SPOKANE STATION ON SPOKANE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 359, is located at the bridge of Oregon Railway and Navigation Company at Spokane, Washington. The rod of the wire gage is fastened to the upper guard rail in the west span of the bridge. The distance from the end of the weight to the index is 22.0 feet, and from the zero of the rod to the outside edge of the pulley 1.80 feet. The gage was connected with a bench mark of the city engineering department and referred to sea level, the rod datum being 1,880 feet above sea level. The channel is straight for some distance above and below the section. The bed is gravelly and is practically unchangeable. The banks are high and are only overflowed during extraordinary floods. The velocity is quite swift, even during low water. The observer is Z. Taylor, telegraph operator, residing within 400 feet of the bridge. The following discharge measurements were made in 1897 by Cyrus C. Babb and others:

May 20, gage height, 10.80 feet; discharge, 29,084 second-feet.
June 29, gage height, 5.16 feet; discharge, 9,026 second-feet.
July 21, gage height, 4.05 feet; discharge, 7,893 second-feet.
September 11, gage height, 1.92 feet; discharge, 2,575 second-feet.
October 20, gage height, 1.50 feet; discharge, 2,011 second-feet.

Daily gage height, in feet, of Spokane River at Spokane, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.50	4.00	3.20	4.75	11.10	8.60	5.00	3.20	1.90	1.70	1.45	5.00
2	5.40	4.00	3.15	4.80	10.90	8.40	4.95	3.10	1.90	1.70	1.45	4.90
3	5.30	4.00	3.15	4.90	10.50	8.20	4.95	3.05	1.90	1.65	1.45	4.80
4	5.20	4.00	3.15	4.90	10.50	7.85	4.95	3.00	1.85	1.65	1.45	4.60
5	5.20	3.90	3.15	5.05	10.40	7.60	5.00	3.00	1.85	1.60	1.45	4.50
6	5.00	3.80	3.15	5.20	10.40	7.10	5.00	2.95	1.85	1.60	1.45	4.60
7	5.00	3.75	3.15	5.30	10.60	6.70	5.00	2.85	1.85	1.60	1.45	4.70
8	4.80	3.75	3.15	5.45	10.90	6.50	5.00	2.75	1.90	1.60	1.45	5.00
9	4.80	3.70	3.15	5.50	11.20	6.30	5.00	2.70	1.95	1.55	1.50	5.40
10	4.70	3.70	3.10	5.70	11.20	6.20	5.00	2.65	1.95	1.55	1.50	5.70
11	4.60	3.65	3.10	6.10	10.90	6.15	4.90	2.65	1.90	1.50	1.50	5.90
12	4.50	3.60	3.10	6.70	10.60	6.05	4.90	2.60	1.90	1.50	1.60	6.00
13	4.35	3.60	3.00	7.00	10.40	5.90	4.80	2.50	1.90	1.50	1.80	6.00
14	4.30	3.60	2.95	7.30	10.30	5.70	4.70	2.50	1.90	1.50	2.45	6.00
15	4.25	3.60	2.90	7.60	10.20	5.50	4.60	2.45	1.90	1.50	2.80	6.00
16	4.20	3.55	2.90	8.00	10.30	5.40	4.50	2.40	1.85	1.50	3.00	6.00
17	4.20	3.55	2.90	8.50	10.50	5.35	4.40	2.35	1.80	1.50	3.05	5.90
18	4.00	3.55	2.90	8.90	10.70	5.30	4.30	2.30	1.80	1.50	3.20	5.80
19	4.00	3.50	2.90	9.40	10.80	5.40	4.20	2.25	1.80	1.50	3.40	5.70
20	3.90	3.50	2.90	10.20	10.95	5.40	4.15	2.25	1.75	1.50	3.90	5.50
21	3.80	3.50	2.85	11.00	10.95	5.40	4.05	2.20	1.75	1.50	4.90	5.35
22	3.90	3.50	2.85	11.60	10.85	5.45	4.00	2.20	1.75	1.50	5.40	5.20
23	3.80	3.50	2.90	11.80	10.70	5.45	3.90	2.15	1.75	1.50	5.60	5.00
24	3.85	3.45	2.90	11.80	10.50	5.40	3.80	2.10	1.75	1.45	5.70	4.90
25	4.00	3.30	2.90	11.60	10.30	5.40	3.70	2.05	1.70	1.45	5.70	4.80
26	4.05	3.25	3.15	11.40	10.10	5.40	3.60	2.05	1.70	1.45	5.65	4 70
27	4.00	3.25	3.60	11.15	9.80	5.30	3.50	2.00	1.70	1.45	5.60	4.55
28	3.90	3.20	4.10	11.30	9.50	5.30	3.45	2.00	1.70	1.45	5.40	4.60
29	4.00	.....	4.40	11.30	9.25	5.20	3.35	1.95	1.70	1.45	5.25	4.65
30	4.00	.....	4.60	11.30	9.05	5.10	3.20	1.95	1.70	1.45	5.10	5.00
31	4.00	.....	4.65	.....	8.80	.....	.....	1.90	.....	1.45	.....	5.40

WENATCHEE STATION ON WENATCHEE RIVER.

This station is located on the Wenatchee River at the wagon bridge, 6 miles above its mouth and 7 miles from Wenatchee, Washington. It was established November 1, 1897. The rod is vertical and fastened to the face of the second wooden pier from the north. Observations of heights were taken at the bridge site of the Wenatchee Waterpower Company by C. Nasten, engineer in charge, 5 miles below the station, and reduced to the station gage by having simultaneous readings at both points on September 13, November 1, 14, and 20, respectively. Both banks of the river at the station are high and not liable to overflow. The bed of the river is composed of bowlders and the current is quite swift, even at low stages. The canal of the Wenatchee Waterpower Company is taken out about 1 mile above the station. The following are the discharge measurements made in 1897 by Cyrus C. Babb and C. Nasten:

September 13, gage height, 0.30 foot; discharge, 900 second-feet.
November 1, gage height, 0.00 feet; discharge, 706 second-feet.
November 14, gage height, 1.24 feet; discharge, 2,770 second-feet.
November 20, gage height, 5.10 feet; discharge, 13,280 second-feet.

Daily gage height, in feet, of Wenatchee River at Wenatchee, Washington, for 1897.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	0.22	0.00	12	.....	.....	0.00	2.18	23	.....	0.36	0.30	.....
2	.....	.....	.15	.00	13	.....	0.30	.35	1.65	24	.....	.35	.....	.....
3	.....	.....	.....	.00	14	.....	.....	.30	1.25	25	.....	.52	.22	.....
4	.....	.....	.00	.00	15	.....	.....	.20	.....	26	0.82	.....	.12	.....
5	.....	.....	.00	.00	16	0.95	.15	.00	.....	27	.....	.38	.08	.....
6	.....	.....	.00	.00	17	.....	.15	.....	.....	28	.....	.38	.....	.....
7	1.22	.....	.00	.00	18	.....	.15	.00	.....	29	.....	.36	.00	.....
8	.....	0.45	.00	.....	19	.....	.....	.00	.....	30	.....	.30	.00	.....
9	.....	.....	.00	.....	20	.....	.25	.00	5.10	31	.....	.....	.....	.....
10	.....	.....	.....	.....	21	.....	.32	.00	.....					
11	.....	.....	.00	.....	22	.....	.35	.22	.....					

WHITMAN STATION ON WALLAWALLA RIVER.

This station, located on Wallawalla River, 7 miles below Wallawalla, Washington, was established July 19, 1897, for the purpose of determining the amount of water available for the several canals taken out below. The gage is an unusual form, consisting of a horizontal timber 4 inches square by 14 feet long, fastened to two vertical posts 6 feet apart and set in the ground at the edge of the bank of the river, with one end of the timber projecting out over the water. On this horizontal timber is then placed a wire gage. The distance from the end of the weight to the wire index is 19.62 feet and the outside edge of the pulley at the end of the timber is 4.27 feet from the zero. The bench mark is a nail driven into the southwest corner of the barn, 70 feet north of the gage, and 1 foot above the sill. Its elevation is 11.00 feet above datum. Discharge measurements are to be taken from a foot suspension bridge, near by. The channel is gravelly and the banks medium high. The observer is Mrs. W. F. York, post office, Wallawalla, Washington. A gaging on August 26,1897, was made by Sydney Arnold; gage height, 0.86 feet; discharge, 78 second-feet.

Daily gage height, in feet, of Wallawalla River at Whitman, Washington, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.90	0.95	1.20	1.30	2.35	17	.....	0.88	1.15	1.25	1.90	2.55
2	.....	.88	.98	1.20	1.30	2.22	18	.....	.88	1.15	1.20	2.08	2.35
3	.....	.88	1.00	1.20	1.30	2.12	19	1.00	.82	1.15	1.20	2.32	2.20
4	.....	.88	1.00	1.20	1.30	2.02	20	1.00	.82	1.15	1.20	2.35	2.20
5	.....	.88	1.05	1.20	1.30	2.18	21	1.00	.88	1.15	1.20	2.28	2.15
6	.....	.88	1.15	1.20	1.30	2.35	22	1.00	.82	1.15	1.20	2.15	2.10
7	.....	.88	1.15	1.20	1.30	2.92	23	1.00	.82	1.15	1.25	2.15	2.05
8	.....	.88	1.20	1.20	1.30	3.05	24	1.00	.82	1.15	1.25	2.12	2.05
9	.....	.88	1.20	1.20	1.30	2.88	25	1.00	.82	1.15	1.25	2.05	2.05
10	.....	.88	1.18	1.20	1.38	2.68	26	.98	.82	1.15	1.25	1.98	2.12
11	.....	.88	1.15	1.20	1.95	2.80	27	.95	.82	1.15	1.30	1.90	2.25
12	.....	.88	1.15	1.20	1.90	2.88	28	.92	.82	1.15	1.30	1.85	2.75
13	.....	.88	1.15	1.22	2.05	2.80	29	.88	.82	1.15	1.30	1.85	3.20
14	.....	.88	1.15	1.30	2.02	3.00	30	.86	.85	1.20	1.30	2.20	3.75
15	.....	.88	1.15	1.30	1.92	2.88	31	.88	.90	.....	1.30	.....	3.28
16	.....	.88	1.15	1.25	1.90	2.72							

GIBBON STATION ON UMATILLA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 361, is located about one-half mile west of the railroad station at Gibbon, Oregon. The lower section of the old gage rod was carried out by the floods in March, but a temporary rod was used until a permanent one was placed June 12, 400 feet downstream. It consists of a substantial rod 4 inches square by 14 feet long fastened to a rock by two one-half-inch bolts, soldered into holes, drilled into the rock. The bench mark for this new gage is a cross in black paint on the highest point of the rock to which the rod is fastened. Its elevation is 4.40 feet above datum, also marked on the rock. One foot in elevation on the rod is equal to 2.71 feet along its length. The section under the cable, at which discharge measurements were made, was also so modified by the March freshets that it was found necessary to remove the cable and car to a better location one-quarter of a mile below. The channel here is straight for a distance above and below. The bed of the river is gravelly. The initial point for soundings is on the right bank. The observer is W. Swart, telegraph operator at Gibbon. The following discharge measurements were made in 1897 by Cyrus C. Babb:

May 5, gage height, 4.10 feet; discharge, 2,141 second-feet.
May 22, gage height, 2.05 feet; discharge, 624 second-feet.
May 27, gage height, 1.36 feet; discharge, 448 second-feet.
June 7, gage height, 1.00 foot; discharge, 233 second-feet.
June 12, gage height, 0.80 foot; discharge, 168 second-feet.
July 5, gage height, 1.16 feet; discharge, 265 second-feet.
July 20, gage height, 0.59 foot; discharge, 118 second-feet.
August 27, gage height, 0.30 foot; discharge, 83 second-feet.

Daily gage height, in feet, of Umatilla River at Gibbon, Oregon, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.80	1.80	3.05	3.40	1.20	0.85	0.45	0.40	0.35	0.40	2.00
2	1.75	2.00	2.00	3.05	3.40	1.15	1.05	.45	.35	.35	.40	1.90
3	1.70	2.60	1.90	3.00	3.50	1.10	1.30	.45	.35	.35	.40	1.80
4	1.70	2.80	1.90	3.00	3.75	1.10	1.20	.45	.35	.35	.40	1.70
5	1.65	2.90	1.90	3.20	4.10	1.00	1.15	.45	.35	.35	.40	1.80
6	1.65	2.90	1.80	3.40	4.40	1.00	1.10	.45	.50	.35	.40	2.00
7	1.60	2.80	1.80	3.50	3.55	1.00	1.00	.45	.45	.35	.40	2.85
8	1.60	2.50	1.70	3.70	3.20	1.00	.95	.45	.45	.35	.45	2.90
9	1.60	2.40	1.70	4.00	3.00	.90	.90	.45	.40	.35	.50	2.60
10	1.60	2.90	1.60	5.00	3.00	.85	.85	.45	.40	.35	.80	2.60
11	1.55	2.80	1.55	4.90	3.10	.85	.80	.45	.40	.35	.90	2.50
12	1.55	2.90	1.55	4.80	3.10	.80	.80	.45	.40	.40	.95	2.50
13	1.55	3.10	1.50	4.70	3.20	.80	.75	.45	.35	.40	1.30	2.50
14	1.55	3.10	1.50	5.05	3.10	.80	.70	.45	.35	.40	1.20	2.45
15	1.55	2.95	1.50	5.38	3.05	1.10	.70	.40	.35	.40	1.05	2.20
16	1.50	2.80	1.60	5.50	3.00	1.25	.65	.40	.35	.40	1.05	1.90
17	1.50	2.50	1.70	6.00	3.15	1.15	.65	.40	.35	.35	1.20	1.70
18	1.50	2.40	1.70	6.05	2.90	1.10	.60	.40	.35	.35	2.00	1.70
19	1.70	2.20	1.70	5.65	2.60	1.00	.60	.35	.30	.35	1.90	1.70
20	1.65	2.20	1.65	4.70	2.40	.95	.60	.35	.30	.40	2.00	1.65
21	1.65	1.90	1.65	3.95	2.20	.95	.55	.35	.30	.40	1.80	1.50
22	1.65	1.80	1.65	3.70	2.02	.90	.55	.35	.30	.40	1.60	1.40
23	1.65	1.65	1.60	3.70	1.80	.85	.50	.35	.30	.40	1.60	1.40
24	1.60	1.60	3.05	3.60	1.85	.85	.50	.35	.30	.45	1.50	1.30
25	1.60	1.50	5.65	3.60	1.50	.85	.50	.35	.30	.45	1.40	1.25
26	1.60	1.60	5.05	4.40	1.35	1.00	.50	.35	.30	.40	1.30	1.80
27	1.60	1.60	4.20	4.40	1.25	.95	.45	.30	.35	.40	1.30	2.20
28	1.65	1.65	3.80	3.90	1.25	.90	.45	.30	.35	.40	1.20	2.80
29	1.65	.....	3.60	3.60	1.20	.85	.45	.30	.35	.40	1.40	3.50
30	1.70	.....	3.35	3.50	1.20	.85	.45	.30	.35	.40	2.00	3.70
31	1.75	.....	3.15	.....	1.20	.....	.45	.50	.....	.40	.....	3.40

MORO STATION ON DESCHUTES RIVER.

This station is located on the Deschutes River, near Moro, Oregon, 16 miles east of The Dalles, Oregon, at the ranch of the observer, J. E. Harris, 3 miles above what is known as the "free bridge." The rod is inclined. The bench mark is the head of a nail, at elevation 8.41 feet, in the large alder tree to which the rod is spiked. The discharge measurements are taken at the iron bridge below. The section here is poor, owing to the swift current. The bed is rocky and uneven. A measurement made on September 27, 1897, by Cyrus C. Babb, gave gage height, 2.10 feet; discharge, 5,962 second-feet.

Daily gage height, in feet, of Deschutes River at Moro, Oregon, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	2.00	2.20	12	.....	2.50	3.40	23	2.10	2.50	2.50
2	.....	2.00	2.20	13	.....	2.50	3.20	24	2.00	2.40	2.40
3	.....	2.00	2.10	14	.....	2.40	4.10	25	2.00	2.30	2.40
4	.....	2.00	2.10	15	.....	2.40	3.40	26	2.00	2.30	2.40
5	.....	2.10	2.10	16	.....	2.40	3.20	27	2.00	2.20	2.80
6	.....	2.20	2.30	17	.....	2.50	3.10	28	2.00	2.20	2.70
7	.....	2.30	3.30	18	.....	2.60	3.00	29	2.00	2.20	3.10
8	.....	2.30	3.40	19	2.00	2.80	2.80	30	2.00	2.10	3.00
9	.....	2.30	3.40	20	2.10	3.10	2.60	31	2.10	2.10	2.10
10	.....	2.40	3.20	21	2.00	2.80	2.60				
11	.....	2.40	3.20	22	2.10	2.50	2.50				

TUCKERS STATION ON HOOD RIVER.

This station is located at Tuckers, 5 miles south of Hood River, Oregon. It was established October 20, 1897, by Cyrus C. Babb. The gage is of the wire type. The rod is nailed to a wooden member of the bridge. The length of the gage wire is 33.85 feet, and the pulley is 2 feet from end of rod. At gage height 1.50 the water is 30.10 feet below edge of floor at side of inner inclined wooden brace at station 4.5 feet from east end, lower side. The bottom is a rock ledge and the sides are precipitous. The observer is B. R. Tucker, proprietor of a sawmill. Measurements were made as follows in 1897 by Cyrus C. Babb:

September 28, gage height, 1.70 feet; discharge, 541 second-feet.
October 20, gage height, 1.50 feet; discharge, 459 second-feet.

Daily gage height, in feet, of Hood River at Tuckers, Oregon, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	1.60	3.40	12	.....	5.20	5.10	23	1.80	3.50	2.90
2	.....	1.50	3.00	13	.....	5.70	5.00	24	1.90	3.10	2.90
3	.....	1.50	2.80	14	.....	3.80	6.50	25	1.80	2.90	3.40
4	.....	1.50	2.70	15	.....	3.20	5.40	26	1.70	2.90	4.00
5	.....	1.70	6.70	16	.....	3.00	5.00	27	1.60	2.60	5.00
6	.....	1.80	7.50	17	.....	4.20	4.50	28	1.60	2.50	8.97
7	.....	1.60	7.30	18	.....	9.00	3.90	29	1.60	2.70	7.60
8	.....	1.70	7.00	19	.....	7.80	3.90	30	1.60	4.00	6.00
9	.....	2.10	5.50	20	1.50	5.60	3.50	31	1.60		5.40
10	.....	4.60	5.00	21	1.90	5.20	3.50				
11	.....	4.80	4.90	22	1.80	4.10	3.10				

SEGUIN STATION ON DUNGENESS RIVER.

This station is located at a county bridge near Seguin Post-office, 18 miles southeast of Port Angeles, Washington, and 9 miles above the mouth of the river. It was established July 5, 1897, by A. Judson Adams. The gage consists of a vertical rod fastened to the down-stream side of the crib abutment on the right bank of the river. The bench mark is a spike in the root of a fir stump 4 feet in diameter, about 20 feet north of north end of bridge, the elevation being 12.75 feet above gage datum. The initial point for sounding is on the right bank. The channel is straight for some distance above and below the station. The right bank is high and not liable to overflow. The left bank is low and is flooded during freshets. The observer is David Duncan, farmer. Discharge measurements were made as follows by A. Judson Adams in 1897:

July 5, gage height, 5.06 feet; discharge, 546 second-feet.
August 17, gage height, 4.81 feet; discharge, 357 second-feet.
November 4, gage height, 4.36 feet; discharge, 165 second-feet.

Daily gage height, in feet, of Dungeness River at Seguin, Washington, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	.....	4.70	4.60	4.30	4.50	4.20	17.....	4.95	4.80	4.35	4.20	5.80	4.20
2....	.....	4.70	4.50	4.25	4.40	5.20	18.....	4.90	4.80	4.40	4.20	8.10	4.10
3....	.....	4.70	4.55	4.25	4.40	5.10	19.....	4.90	4.85	4.40	4.20	6.60	4.00
4....	.....	4.75	4.55	4.30	4.35	5.10	20.....	5.00	4.85	4.30	4.30	5.90	4.00
5....	5.05	4.80	4.50	4.25	4.35	5.70	21.....	4.95	4.90	4.35	4.25	5.70	3.90
6....	5.10	4.80	4.50	4.25	4.40	6.25	22.....	4.90	4.80	4.40	4.75	5.50	3.90
7....	5.05	4.80	4.40	4.20	4.40	7.40	23.....	4.90	4.80	4.40	5.05	5.40	3.90
8....	5.00	4.80	4.40	4.20	4.30	6.10	24.....	4.90	4.75	4.40	4.70	5.35	3.95
9....	5.00	4.80	4.40	4.20	4.40	5.50	25.....	4.85	4.70	4.40	4.60	5.30	3.90
10....	5.00	4.80	4.35	4.25	4.35	5.20	26.....	4.80	4.55	4.40	4.50	5.20	3.80
11....	5.10	4.80	4.35	4.30	5.05	5.20	27.....	4.80	4.55	4.40	4.50	5.20	7.90
12....	5.20	4.75	4.35	4.40	5.05	5.00	28.....	4.80	4.60	4.40	4.45	5.10	5.80
13....	5.05	4.70	4.40	4.30	4.85	8.00	29.....	4.80	4.55	4.40	4.45	5.20	5.50
14....	5.05	4.70	4.40	4.25	4.85	5.20	30.....	4.80	4.55	4.35	4.45	5.30	5.00
15....	5.05	4.70	4.40	4.20	4.60	4.60	31.....	4.75	4.75	.....	4.40	.....	4.80
16 ...	5.00	4.80	4.35	4.20	4.60	4.35							

McDONALD STATION ON ELWHA RIVER.

This station is located 9 miles southwest of Port Angeles at McDonald, Clallam County, Washington, at the new county bridge and was established October 8, 1897, by A. Judson Adams. The horizontal rod of the wire gage is nailed to the railing of the north side of the bridge, the 9-foot mark being opposite the fourth upright post counting from the east end of the bridge. The length of the gage wire is 49.26 feet, and the distance from the end of the rod to outside edge of pulley is 7.92 feet. The bench mark is the top edge of the top side-rail on the north side of the bridge at the third upright post from the east end of the bridge, and its elevation is 41.34 feet above gage datum. The initial point for soundings is on the right bank. The channel is straight for some distance above and below the station. Both banks are high and rocky and will not overflow. The bed of the stream is rocky. The observer is Thomas H. Stringham, postmaster at McDonald. The following measurements of discharge were made by A. Judson Adams in 1897:

October 8, gage height, 0.95 foot; discharge, 406 second-feet.
December 28, gage height, 8.00 feet; discharge, 4,623 second-feet.

Daily gage height, in feet, of Elwha River at McDonald, Washington, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	1.20	2.40	12	1.10	2.40	3.45	23	2.50	2.55	2.00
2	.....	1.15	2.00	13	1.22	2.20	3.60	24	1.60	2.35	2.10
3	.....	1.15	1.45	14	.95	2.15	4.60	25	1.35	2.10	2.35
4	.....	1.20	2.50	15	.90	2.05	3.80	26	1.35	1.95	2.55
5	.....	1.25	2.35	16	.85	1.95	3.20	27	1.30	1.90	6.90
6	.....	1.22	4.50	17	.85	2.05	3.50	28	1.30	1.45	8.95
7	.....	1.22	6.40	18	.80	14.50	2.50	29	1.25	2.50	6.87
8	1.00	1.25	5.20	19	1.25	5.40	2.45	30	1.25	2.90	4.55
9	1.00	3.30	4.30	20	1.45	4.00	2.40	31	1.20	.....	.....
10	1.00	2.45	4.25	21	2.65	3.30	2.50				
11	1.00	3.60	3.95	22	2.20	3.05	2.10				

FORKS STATION ON CALOWA RIVER.

This station is located at the county highway bridge in the southwestern part of Clallam County near Forks, Washington, and is reached by steamer to Clallam Bay, thence overland 30 miles by wagon. It was established November 12, 1897, by A. Judson Adams. The horizontal rod of the wire gage is nailed to the railing of the wagon bridge. Both banks are high and rocky and do not overflow. The bed of the stream is gravelly. The observer is H. C. Whittier, a farmer, post-office, Forks, Washington. The following discharge measurements were made by A. Judson Adams in 1897:

September 6, gage height, —— feet; discharge, 467 second-feet.
November 12, gage height, 3.66 feet; discharge 1,494 second-feet.

Daily gage height, in feet, of Calowa River at Forks, Washington, for 1897.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	4.00	9	.....	6.45	17	10.60	3.75	25	3.00	3.95
2	.....	3.80	10	.....	6.50	18	17.00	3.30	26	2.15	4.70
3	.....	3.00	11	.....	7.10	19	7.25	2.90	27	3.00	15.90
4	.....	3.85	12	3.85	5.70	20	5.00	2.70	28	2.80	10.50
5	.....	6.70	13	3.90	10.25	21	4.70	2.55	29	3.00	6.65
6	.....	6.45	14	3.40	8.00	22	4.05	2.40	30	6.40	5.00
7	.....	9.60	15	2.95	5.40	23	5.55	2.35	31	.....	4.10
8	.....	9.40	16	2.70	4.30	24	3.10	2.40			

QUILLAYUTE STATION ON SOLDUCK RIVER.

This station is located at the county highway bridge about 9 miles northeast of Lapush, in southwestern part of Clallam County, near Quillayute, Washington, and was established November 13, 1897, by A. Judson Adams. The horizontal rod of the wire gage is fastened to the railing of the wagon bridge. The channel is straight for some distance above and below the station. The banks are high and rocky and do not overflow. The bed of the stream is composed of rocks and gravel. The observer is Peter Van Bossche, a farmer, address Quillayute, Washington. The following measurements were made by A. Judson Adams in 1897:

September 7, gage height, —— feet; discharge, 858 second-feet.
November 13, gage height, 4.00 feet; discharge, 1,898 second-feet.

Daily gage height, in feet, of Solduck River at Quillayute, Washington, for 1897.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	4.95	9	.....	7.15	17	3.95	4.75	25	3.75	4.20
2	.....	4.30	10	.....	6.45	18	11.90	4.35	26	3.65	4.60
3	.....	3.90	11	.....	7.10	19	8.35	4.05	27	3.60	9.80
4	.....	3.65	12	.....	6.35	20	5.90	3.80	28	3.40	14.30
5	.....	6.80	13	4.00	7.55	21	5.40	3.60	29	3.50	8.40
6	.....	5.45	14	3.45	8.90	22	4.90	3.45	30	5.55	6.35
7	.....	9.10	15	3.10	6.30	23	4.40	3.30	31	.....	5.50
8	.....	8.95	16	2.90	5.40	24	4.00	3.30			

JELLYS FERRY STATION ON SACRAMENTO RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 365, is located about 12 miles above the town of Redbluff, California, at a crossing of a county road at Jellys Ferry. The observer, Fred Lemstrom, is the ferryman. The ferry cable is used in the discharge measurements. The gage consists of a vertical rod marked to tenths of a foot. It is made in three sections and nailed firmly to trees. Besides the gage rod at this point, another rod is located 1,206 feet upstream from the gage and another 350 feet downstream, in order to determine the slope of the water surface. Bench mark No. 1 is on an oak tree on the left bank 1,206 feet upstream from the ferry and 65 feet north of the upper rod, and is 22.724 feet above gage datum. Bench mark No. 2 is on an oak tree on the left bank of the river 300 feet below the cable, and is 22.429 feet above gage datum. The channel for 1,000 feet above and below the station is nearly straight. The right bank is high, but the left bank is liable to overflow when the water rises above the 25-foot mark. The bed of the stream consists of gravel, and changes slightly. The following discharge measurements were made in 1897 by J. B. Lippincott and Fred Lemstrom:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Mar. 13...	10.30	18,568	June 28 ...	6.42	6,493	Oct. 28...	5.70	4,202
Mar. 29...	14.40	28,319	July 13...	5.95	5,032	Nov. 13 ...	5.70	4,196
Apr. 3...	10.85	21,519	July 28....	5.70	5,082	Nov. 28 ..	5.95	6,179
Apr. 16...	12.20	25,806	Aug. 13....	5.60	4,285	Dec. 13...	7.40	10,151
Apr. 30...	10.30	18,544	Aug. 28....	5.50	4,490	Dec. 17...	6.85	8,195
May 14...	9.00	14,719	Sept. 13 ...	5.50	4,257	Dec. 17...	6.85	8,802
May 28...	7.50	10,193	Sept. 28 ...	5.50	4,418	Dec. 28...	5.95	6,105
June 11 ..	6.50	7,277	Oct. 13	5.60	4,591			

REDBLUFF STATION.

This station, as described in the Eighteenth Annual Report, Part IV, page 362, is located at the wagon bridge in the town of Redbluff, California. The observations of gage heights are maintained by the Weather Bureau and are taken by Maurice Connell. The vertical rod, 30 feet long, is nailed to a large sycamore tree on the left bank of the river about 25 feet above the bridge.

Daily gage height, in feet, of Sacramento River at Jellys Ferry, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	13.10	19.75	16.45	12.65	10.20	7.15	6.25	5.70	5.50	5.50	5.70	5.90
2	11.25	19.20	13.45	11.35	10.05	7.10	6.20	5.70	5.50	5.60	5.70	5.90
3	10.25	18.70	12.35	10.85	9.90	7.00	6.20	5.70	5.50	5.60	5.70	5.80
4	9.50	20.53	11.60	10.55	9.90	6.95	6.20	5.70	5.50	5.50	5.70	5.80
5	9.00	23.77	11.90	10 50	9.95	6.90	6.15	5.60	5.50	5.50	5.70	5.80
6	8.65	22.60	11.75	10.70	9.95	6.80	6.10	5.60	5.50	5.50	5.70	6.00
7	8.45	20.30	12.20	11.20	9.60	6.70	6.10	5.60	5.50	5.50	5.70	6.50
8	8.25	16.90	11.95	11.25	9.25	6.70	6.10	5.60	5.50	5.50	5.70	9.70
9	8.05	15.40	11.75	11.35	9.00	6.60	6.10	5.60	5.50	5.50	5.70	7.80
10	7.85	14.00	11.20	11.55	8.95	6.50	6.00	5.60	5.50	5.50	5.70	7.20
11	7.75	12.75	10.60	12.00	9.20	6.50	6.00	5.60	5.50	5.50	5.70	8.40
12	7.60	12.25	10.30	12.05	9.05	6.50	6.00	5.60	5.50	5.50	5.70	8.30
13	7.65	11.55	9.85	12.00	9.05	6.40	6.00	5.60	5.50	5.60	5.70	7.40
14	7.60	11.15	9.55	11.95	9.00	6.40	5.90	5.60	5.50	5.60	5.70	8.90
15	7.50	11.00	9.45	12.10	8.85	6.55	5.90	5.60	5.50	5.60	5.70	7.60
16	7.40	13.10	9.65	12.20	8.80	6.50	5.90	5.60	5.50	5.60	5.70	7.20
17	7.25	12.00	9.75	12.15	8.65	6.40	5.90	5.60	5.50	5.60	5.70	6.80
18	7.10	11.30	9.60	12.25	8.50	6.30	5.80	5.50	5.50	5.60	5.70	6.60
19	7.00	13.90	9.55	12.45	8.30	6.35	5.80	5.50	5.50	5.60	5.70	6.50
20	7.00	13.20	9.55	13.05	8.30	6.80	5.80	5.50	5.50	5.60	6.10	6.40
21	6.95	11.55	9.10	12.10	8.20	7.20	5.80	5.50	5.50	5.70	6.30	6.30
22	6.90	10.65	8.85	11.55	8.10	6.95	5.80	5.50	5.50	5.70	6.00	6.10
23	6.90	10.15	8.65	11.15	8.00	6.85	5.80	5.50	5.50	6.00	7.00	6.10
24	6.95	9.85	8.50	10.85	8.00	6.65	5.80	5.50	5.50	6.30	6.60	6.10
25	7.00	9.90	8.70	10.80	7.90	6.55	5.80	5.50	5.50	5.80	6.80	6.00
26	6.90	10.00	10.15	11.00	7.70	6.50	5.70	5.50	5.50	5.80	6.10	6.00
27	6.90	10.10	10.10	11.20	7.50	6.50	5.70	5.50	5.50	5.70	6.00	5.90
28	7.45	10.00	15.90	11.00	7.45	6.40	5.70	5.50	5.50	5.70	5.90	5.90
29	17.45	.....	14.55	10.65	7.30	6.40	5.70	5.50	5.50	5.70	5.90	5.90
30	13.95	.....	13.10	10.30	7.30	6.30	5.70	5.50	5.50	5.70	5.90	5.90
31	13.80	.....	12.15	.....	7.20	.....	5.70	5.50	.....	.....	.....	5.90

Daily gage height, in feet, of Sacramento River at Redbluff, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.2	16.0	13.6	7.9	6.0	2.3	1.0	0.1	0.6	0.0	0.3	0.4
2	6.1	15.6	11.0	7.6	6.1	2.3	1.0	.1	.7	.2	.3	.4
3	5.7	14.0	8.6	7.4	6.9	2.3	1.0	.1	.3	.3	.5	.6
4	5.2	17.7	8.0	6.5	6.8	2.0	1.0	.1	.2	.2	.5	.7
5	4.9	20.7	7.8	6.1	6.6	2.0	1.0	.1	.1	.1	.5	1.3
6	4.4	21.6	7.8	6.1	6.3	2.0	.9	.1	.1	.1	.4	3.2
7	4.3	15.5	7.0	5.8	5.9	1.9	.9	.1	.1	.1	.3	3.4
8	4.1	13.2	6.0	7.1	5.0	1.9	.9	.1	.1	.1	.3	7.2
9	3.9	11.6	7.6	7.0	5.0	1.7	.9	.1	.1	.1	.3	6.5
10	3.6	10.0	6.0	7.4	5.0	1.7	.8	.1	.1	.0	.3	5.3
11	3.4	9.6	6.0	7.8	5.0	1.6	.7	.1	.1	.0	.3	4.4
12	3.0	8.6	6.0	8.0	5.0	1.5	.7	.1	.1	.1	.3	5.0
13	3.2	7.5	5.6	8.0	4.9	1.3	.7	.1	.1	.3	.3	4.9
14	3.0	7.0	5.2	7.8	4.9	1.0	.6	.1	.1	.5	.3	3.9
15	3.1	7.1	5.0	8.0	4.8	1.0	.5	.1	.1	.4	.3	4.0
16	2.4	8.5	5.0	8.0	4.6	1.0	.5	.1	.1	.3	.4	2.0
17	2.2	8.2	5.3	8.1	4.3	1.0	.5	.1	.1	.2	.4	1.9
18	2.1	7.4	5.3	8.1	4.2	1.0	.3	.1	.0	.1	.6	1.6
19	2.0	10.0	5.1	8.1	4.2	1.8	.3	.1	.0	.1	.8	1.6
20	2.0	11.0	4.9	8.0	4.0	2.0	.2	.1	.0	.2	1.0	1.4
21	2.0	7.6	4.6	8.0	4.0	2.9	.2	.1	.0	.4	1.3	1.0
22	2.0	6.7	5.0	8.0	4.0	1.9	.2	.1	.0	1.0	1.4	1.0
23	2.0	6.0	5.2	7.6	4.1	2.0	.1	.1	.0	1.2	.9	1.0
24	2.0	5.9	6.1	7.4	4.1	2.0	.1	.1	.0	1.0	.9	1.0
25	2.0	5.8	6.1	7.1	4.1	1.4	.1	.1	.0	1.0	.4	1.0
26	2.0	5.9	8.6	7.0	4.1	1.4	.1	.1	.0	.8	.4	1.0
27	2.0	5.6	10.7	6.9	3.8	1.0	.1	.1	.0	.7	.4	1.0
28	2.4	6.9	9.0	6.8	3.7	1.0	.1	.0	.0	.6	.4	1.0
29	14.0	.....	8.6	6.6	3.7	1.0	.1	.0	.0	.5	.4	1.0
30	11.1	.....	8.1	6.0	3.7	1.0	.1	.0	.0	.5	.4	1.0
31	10.0	.....	8.4	.....	3.7	.....	.1	.0	.....	.3	.....	.9

OAKDALE STATION ON STANISLAUS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 371, is located at the wagon bridge one-half mile north of the town of Oakdale, California. One gage rod is set between the south or left hand piers of the wagon bridge on the side toward the water, and can be read from the bridge. The datum is 27.92 feet below the top of the southeast iron pier of the wagon bridge. A rod for the lowest readings of the river is 125 feet below the wagon bridge on the left bank and referred to the same datum. A secondary gage for determining the slope of the river is attached to the crib abutment of the Southern Pacific Railroad bridge, 1,071 feet below the wagon bridge and referred to the same datum as the upper gage. Its zero is 5.92 feet below the top of the cap on the piles of the south crib pier of the railroad bridge. This pier has settled during the last year. The channel of the river is uniform and straight above and below the station, and both banks are high enough to prevent overflow in all except extreme conditions of flood. The bed of the stream at this point is of sand and gravel and changes only slightly. The observer is Frank Templin. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

February 16, gage height, 4.22 feet; discharge, 1,346 second-feet.
May 30, gage height, 8.60 feet; discharge, 6,754 second-feet.
July 14, gage height, 3.20 feet; discharge, 1,015 second-feet.
September 5, gage height, 2.00 feet; discharge, 144 second-feet.
October 29, gage height 2.40 feet; discharge, 223 second-feet.
December 19, gage height 3.00 feet; discharge, 429 second-feet.

Daily gage height, in feet, of Stanislaus River at Oakdale, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.60	8.66	5.00	5.60	8.40	6.60	3.80	2.40	2.20	1.90	2.20	2.50
2	3.30	8.52	4.70	5.00	9.53	6.20	3.90	2.40	2.20	2.00	2.20	2.50
3	3.10	6.10	4.60	4.90	10.11	6.00	4.00	2.40	2.10	2.00	2.30	2.50
4	3.10	11.20	4.50	4.80	10.80	6.00	3.90	2.40	2.10	2.00	2.30	2.40
5	3.00	9.50	4.40	4.90	10.50	5.90	3.80	2.30	2.00	2.00	2.20	2.40
6	3.00	10.00	4.90	5.10	9.53	5.90	3.80	2.30	2.00	2.00	2.20	2.30
7	3.00	6.90	5.50	5.50	8.80	6.00	3.70	2.30	2.00	2.00	2.30	2.40
8	3.00	6.20	5.10	5.60	8.20	6.40	3.50	2.30	2.00	2.00	2.30	2.70
9	3.00	5.50	4.90	5.90	8.50	6.50	3.50	2.30	2.00	2.00	2.20	4.40
10	3.00	5.10	4.60	6.50	8.40	5.80	3.30	2.30	2.00	2.00	2.20	3.40
11	2.90	4.80	4.40	7.00	9.20	5.40	3.10	2.30	2.00	2.00	2.20	3.10
12	2.90	4.80	4.30	7.40	9.42	5.10	3.20	2.20	2.00	2.00	2.30	3.00
13	3.00	4.50	4.30	7.60	9.13	5.20	3.20	2.20	2.00	2.00	2.30	3.40
14	3.83	4.30	4.10	8.20	9.07	5.40	3.20	2.20	2.00	2.00	2.20	3.60
15	3.10	4.20	4.10	8.70	8.77	4.90	3.20	2.20	2.00	2.20	2.20	3.20
16	3.00	4.10	4.10	9.20	8.62	4.50	3.20	2.10	2.00	2.30	2.20	3.00
17	2.90	6.07	4.40	9.80	8.45	4.10	3.20	2.10	1.90	2.20	2.20	2.90
18	2.90	5.00	5.15	10.30	8.20	3.90	3.00	2.10	2.00	2.10	2.20	2.80
19	2.90	5.47	5.13	9.00	8.90	3.90	2.90	2.10	1.90	2.10	2.20	2.80
20	2.90	5.63	4.60	7.90	9.53	3.90	2.80	2.20	1.90	2.10	2.20	2.60
21	2.90	5.00	4.50	7.20	9.03	4.10	2.80	2.30	1.90	2.10	2.10	2.80
22	2.90	4.60	4.30	7.20	9.23	4.00	2.80	2.30	1.90	2.20	3.00	2.70
23	2.90	4.40	4.30	6.80	10.60	3.90	2.70	2.20	1.90	2.20	3.10	2.60
24	2.90	4.30	4.30	6.80	10.10	3.90	2.70	2.20	2.00	2.40	3.50	2.40
25	2.90	4.30	4.50	7.50	9.10	3.90	2.60	2.20	2.00	2.50	3.00	2.70
26	2.90	4.40	4.80	8.70	8.00	3.90	2.60	2.20	2.00	2.40	2.80	2.60
27	2.90	4.50	4.80	9.20	8.00	3.70	2.50	2.20	2.00	2.30	2.60	2.50
28	2.90	5.50	7.40	9.60	8.20	3.60	2.50	2.20	2.00	2.30	2.50	2.80
29	5.15	.....	6.00	8.90	8.20	3.70	2.50	2.20	2.00	2.30	2.40	2.90
30	4.53	.....	5.40	8.80	8.00	3.80	2.50	2.20	1.90	2.20	2.40	2.70
31	4.40	.....	5.10	.....	7.70	.....	2.50	2.20	.....	2.20	.....	2.70

LAGRANGE STATION ON TUOLUMNE RIVER.

This station, described in the Eighteeenth Annual Report, Part IV, page 378, is located at the bridge in the town of Lagrange, California, 32 miles from Modesto. The vertical gage rod is fastened to timbers between the two iron piers on the right bank of the river. The bench mark is a nail driven into the bottom of the west post of the fifth bent south of the south iron cylinder and is 15.31 feet above the zero of the rod. The channel both above and below the bridge is straight for several hundred feet and the velocity of the stream is quite uniform. Both banks are high and not subject to overflow. The bed is of gravel. The observer is Cleo Pereira. The following is a list of discharge measurements made by J. B. Lippincott and A. Q. Campbell in 1897:

February 15, gage height, 5.80 feet; discharge, 1,864 second-feet.
May 29, gage height, 9.25 feet; discharge, 11,594 second-feet.
July 12, gage height, 5.70 feet; discharge, 1,839 second-feet.
September 7, gage height, 4.00 feet; discharge, 95 second-feet.
October 30, gage height, 4.73 feet; discharge, 534 second-feet.
December 20, gage height, 4.85 feet; discharge 614 second-feet.

Daily gage height, in feet, of Tuolumne River at Lagrange, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.55	8.95	6.80	6.50	8.70	8.30	6.60	4.70	4.10	3.80	4.70	5.30
2	5.25	8.85	6.40	6.40	8.90	8.00	6.70	4.60	4.10	3.80	4.70	5.10
3	5.15	9.05	6.40	6.30	9.30	7.90	6.80	4.60	4.10	3.80	4.80	5.00
4	5.20	9.80	6.20	6.40	9.50	8.00	6.80	4.50	4.00	3.80	4.70	4.90
5	5.10	8.95	6.10	6.60	9.70	8.00	6.90	4.50	4.00	3.90	4.70	4.90
6	5.10	8.10	6.80	6.90	9.80	8.20	6.70	4.50	4.00	3.90	4.60	4.80
7	5.10	8.30	6.80	7.00	9.90	8.50	6.50	4.50	4.00	3.90	4.70	4.80
8	5.10	7.10	6.30	7.20	9.50	8.20	6.20	3.80	4.00	3.80	4.60	6.60
9	5.10	6.90	6.30	7.30	9.80	8.20	6.00	4.80	3.90	3.80	4.60	6.30
10	5.00	6.35	6.20	7.40	9.70	8.50	6.40	4.50	4.00	3.80	4.60	5.90
11	5.00	6.20	6.20	7.60	9.00	8.00	6.30	4.50	4.00	4.70	4.60	5.60
12	5.00	6.20	6.10	7.90	9.30	7.60	6.10	4.50	4.00	4.00	4.60	5.80
13	5.05	6.20	6.10	8.20	9.20	7.50	6.20	4.30	4.00	3.80	4.70	5.70
14	5.40	5.95	6.00	8.50	9.10	7.30	5.80	4.30	3.90	3.90	4.60	5.40
15	5.10	5.80	6.00	8.90	9.70	7.00	5.60	4.30	3.90	3.90	4.60	5.50
16	5.10	5.70	6.00	9.30	9.00	6.90	5.50	4.30	3.90	4.40	4.60	5.30
17	5.10	7.00	6.00	9.60	8.80	6.40	5.40	4.10	3.80	4.80	4.60	5.10
18	5.00	6.90	6.70	9.80	8.60	6.20	5.40	4.10	3.80	4.70	4.50	5.10
19	4.90	6.70	7.80	9.90	8.90	6.00	5.40	4.20	3.90	4.30	4.50	5.00
20	4.90	6.80	6.50	8.70	9.20	6.30	5.50	4.30	3.40	3.80	4.40	5.40
21	4.90	6.50	6.60	8.60	9.60	6.40	5.40	4.30	3.40	3.90	6.40	4.80
22	4.95	6.30	6.20	8.40	10.00	6.50	5.30	4.20	3.50	3.90	6.40	4.80
23	5.00	6.10	6.10	8.30	10.10	6.40	5.20	4.20	3.60	3.90	5.70	4.80
24	5.00	6.00	6.30	8.10	10.20	6.20	5.00	4.10	3.80	5.00	5.10	4.80
25	5.00	6.00	6.40	7.50	10.30	6.40	5.00	4.10	3.80	4.70	5.20	4.80
26	5.35	6.20	6.70	7.80	9.00	6.50	4.90	4.10	3.80	4.50	5.20	4.80
27	5.45	6.30	6.70	7.90	9.20	6.50	5.00	4.20	3.80	4.50	5.00	4.80
28	6.40	6.30	9.00	8.20	9.10	6.60	4.90	4.10	3.80	4.50	5.00	4.80
29	6.40	.....	8.70	8.30	9.20	6.70	4.80	4.20	3.80	4.50	5.00	4.80
30	6.55	.....	7.40	8.50	9.30	6.70	4.90	4.10	3.80	4.70	5.00	4.80
31	6.20	.....	6.60	.....	9.00	.....	4.70	4.10	.....	4.70	.....	4.80

MODESTO STATION ON TUOLUMNE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 384, is located one-half mile south of the depot and at the wagon-road bridge at Modesto, California. The gage is a vertical rod 2 by 6 inches, fastened on the south side of the central railroad pier. The top of the rail at the central pier is 46.05 feet above the datum of the gage. The discharge measurements are made from the wagon bridge, 100 feet west of the railroad bridge. The initial point for sounding is at the pier on the right bank. The channel above and below the station is straight, but in the summer stages of the stream the current is very sluggish. The right bank shows indications of overflow. The observer is J. T. Reed. No discharge measurements were made in 1897.

Daily gage height, in feet, of Tuolumne River at Modesto, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.50	11.97	7.42	7.92	13.42	14.37	8.17	4.66	3.70	3.13	4.12	4.58
2	5.63	18.00	8.38	8.25	13.46	13.00	8.42	4.58	3.66	3.21	4.25	4.75
3	5.17	11.79	7.58	7.50	12.33	11.96	8.58	4.54	3.58	3.25	4.37	4.58
4	4.83	9.17	7.46	7.46	14.17	12.04	8.62	4.50	3.54	3.25	4.08	4.54
5	4.79	13.88	6.96	7.71	15.92	12.08	8.17	4.46	3.50	3.17	4.33	4.50
6	4.71	19.25	7.33	7.88	16.54	12.25	7.70	4.37	3.46	3.13	4.12	4.25
7	4.63	12.25	9.83	8.46	16.35	12.62	7.54	4.29	3.38	3.25	4.12	4.48
8	4.67	12.50	8.17	8.92	15.08	12.83	7.12	4.21	3.38	3.17	4.04	4.21
9	4.58	9.29	7.50	9.21	14.54	12.43	6.75	4.12	3.33	3.29	4.04	9.66
10	4.56	8.25	7.25	9.88	13.33	12.08	6.58	4.08	3.33	3.25	4.04	7.33
11	4.48	7.63	7.13	10.46	13.29	12.17	6.50	4.08	3.33	3.21	3.96	6.12
12	4.44	7.33	6.83	11.21	14.29	10.87	6.50	4.17	3.33	3.29	4.08	5.62
13	4.19	7.13	6.63	11.88	15.00	10.66	6.87	4.17	3.25	3.37	4.04	5.54
14	4.75	6.92	6.54	11.96	15.21	11.25	6.83	4.08	3.25	3.37	3.96	6.04
15	5.79	6.46	6.46	11.50	15.79	10.92	6.83	3.96	3.25	3.29	4.12	5.87
16	5.04	6.46	6.54	12.96	15.04	9.42	6.58	3.92	3.25	3.37	4.12	5.58
17	4.88	8.83	6.73	13.54	14.67	8.83	6.70	3.92	3.17	3.62	4.04	5.17
18	4.56	8.63	7.42	14.21	14.04	8.33	6.37	3.83	3.17	3.79	3.92	5.00
19	4.46	8.88	9.86	14.25	13.58	7.92	6.54	3.83	3.17	3.96	3.87	4.87
20	4.38	9.78	8.04	13.04	14.79	7.66	5.83	3.92	3.25	3.87	3.83	4.54
21	4.29	8.58	7.50	11.42	15.79	8.08	5.88	3.83	3.25	3.66	2.92	4.46
22	4.21	7.71	7.08	11.08	16.33	8.12	5.42	3.83	3.17	3.58	8.08	4.37
23	4.13	7.42	6.75	10.50	17.29	8.04	5.25	3.83	3.17	3.54	7.87	4.50
24	4.17	7.21	6.81	9.92	17.75	8.12	5.17	3.96	3.17	3.37	7.08	4.50
25	4.17	7.00	7.08	9.83	17.92	8.17	5.12	4.08	3.17	3.96	7.29	4.33
26	4.13	7.00	7.67	10.83	16.96	8.04	5.00	4.17	3.13	4.50	6.25	4.25
27	4.13	7.25	7.88	11.92	15.46	7.42	4.96	3.96	3.17	4.42	5.58	4.12
28	4.04	7.50	7.75	13.21	14.54	7.58	4.88	3.87	3.17	4.42	5.12	4.04
29	8.45	.....	12.67	13.42	15.08	7.66	4.79	3.79	3.17	4.25	5.04	4.04
30	6.50	.....	9.42	13.25	15.00	7.92	4.75	3.75	3.17	4.12	4.75	4.04
31	6.54	.....	8.25	.....	15.04	.....	4.66	3.75	.....	4.08	.....	4.04

HERNDON STATION ON SAN JOAQUIN RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 385, is located at the wagon bridge half a mile north of Herndon and 12 miles north of Fresno, California, on the Southern Pacific Railroad. The gage consists of a vertical rod fastened to the lower side of the south central railroad bridge pier. The bench mark is at the south end of the wagon bridge trestle on the west side, on a nail in a post 0.2 of a foot above the ground and marked by a "B. M." cut in the post. The elevation above rod datum is 24.12 feet. A gage on the same datum is also painted on the southwest cylinder. The initial point for soundings is on the left bank at the south cylinder. The channel for 900 feet above and 3,000 feet below the bridge is straight and the water has a uniform and moderate velocity. There are no piers in the bed of the stream to disturb the current and the section is a satisfactory one. The right bank is high, rocky, and steep. The bed of the stream is sandy and gravelly. The observer is G. G. Nelson. The following discharge measurements were made by J. B Lippincott and A. Q. Campbell in 1897:

February 14, gage height, 3.58 feet; discharge, 1,117 second-feet.
May 31, gage height, 8.60 feet; discharge, 10,774 second-feet.
July 16, gage height, 4.50 feet; discharge, 3,223 second-feet.
September 8, gage height, 2.66 feet; discharge, 271 second-feet.
November 2, gage height, 2.92 feet; discharge, 515 second-feet.
December 21, gage height, 3.00 feet; discharge, 699 second-feet.

Daily gage height, in feet, of San Joaquin River at Herndon, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.17	4.38	4.00	4.13	7.50	8.37	4.92	3.50	2.83	2.33	2.92	3.00
2	3.00	9.33	4.54	4.38	7.46	7.42	5.21	3.50	2.83	2.50	2.92	3.17
3	3.00	5.17	4.00	4.13	7.67	7.12	5.21	3.42	2.83	2.50	2.92	3.20
4	2.92	4.54	4.00	4.17	8.79	7.29	5.25	3.42	2.63	2.50	2.92	3.20
5	2.96	4.13	4.00	4.21	9.13	7.12	5.00	3.42	2.63	2.50	2.75	3.17
6	3.00	6.46	3.75	4.17	9.25	7.25	5.00	3.29	2.83	2.50	2.75	3.08
7	2.92	5.00	5.29	4.33	9.21	7.12	4.79	3.25	2.75	2.50	2.75	3.00
8	2.92	4.58	4.79	4.46	8.38	7.29	4.50	3.25	2.67	2.50	2.75	3.00
9	2.92	4.13	4.17	5.29	8.25	7.12	4.25	3.37	2.67	2.42	2.66	5.12
10	2.92	4.00	4.00	5.63	8.25	7.04	4.12	3.33	2.54	2.42	2.66	4.75
11	2.92	3.79	4.00	5.71	8.42	6.42	4.12	3.25	2.50	2.42	2.66	3.87
12	3.00	3.67	3.92	6.50	8.58	6.37	4.29	3.25	2.50	2.42	2.66	3.33
13	3.00	3.54	3.83	6.71	9.08	6.50	4.37	3.12	2.50	2.42	2.79	3.04
14	3.00	3.58	3.83	6.83	9.25	6.92	4.79	3.08	2.50	2.50	2.83	3.17
15	3.08	3.50	3.83	7.13	8.96	6.54	4.58	3.00	2.42	2.50	2.75	3.08
16	3.00	3.50	3.75	7.75	8.67	6.21	4.50	3.08	2.33	2.75	2.66	3.12
17	3.00	3.42	3.92	7.79	8.13	5.46	4.33	3.08	2.33	2.75	2.50	3.17
18	3.00	4.13	3.83	8.17	8.21	5.04	4.25	3.08	2.33	2.50	2.50	3.20
19	2.92	4.00	4.75	7.66	8.13	4.70	4.12	3.00	2.38	2.50	2.50	3.08
20	2.92	4.13	4.08	6.87	7.92	4.70	3.96	3.08	2.42	2.50	2.42	3.08
21	2.92	3.96	4.00	6.42	8.83	4.54	3.92	3.08	2.42	2.50	2.42	3.00
22	2.83	3.79	3.92	6.46	9.50	4.42	3.87	3.00	2.38	2.50	5.25	2.92
23	2.83	3.75	3.83	6.29	9.96	4.29	3.83	3.00	2.33	2.50	4.08	2.11
24	2.83	3.58	4.00	6.17	10.17	4.29	3.66	3.00	2.33	2.54	3.50	2.11
25	2.83	3.50	3.92	6.00	9.70	4.33	3.50	3.08	2.33	2.87	4.33	2.83
26	2.83	3.50	4.00	6.71	9.12	4.46	3.50	3.08	2.33	3.08	3.92	2.83
27	2.83	3.42	4.50	7.46	8.58	4.21	3.50	3.08	2.33	3.08	4.54	2.83
28	2.83	3.96	4.29	7.67	8.79	4.21	3.50	3.00	2.33	3.00	3.48	3.17
29	2.83	.....	5.38	7.67	8.87	4.37	3.50	3.00	2.33	2.92	3.04	3.08
30	3.17	.....	4.29	7.54	8.70	4.54	3.50	3.00	2.33	2.92	3.25	3.08
31	3.38	.....	4.08	.....	8.54	.....	3.50	2.92	.....	2.92	.....	3.17

RED MOUNTAIN STATION ON KINGS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 390, is located 15 miles east of Sanger, California, southwest of Red Mountain and 3 miles below Jarrett's place, and may be reached by roads on either side of the river from Sanger. The station is on what is called "Lower Section of No. 9" of the lumber flume. The gage is made of two 4 by 8-inch timbers 14 and 20 feet long, respectively, laid on the ground under a rock and bolted to a tree. The bench mark is a cross cut in the top of a granite bowlder 11 feet northwest of a blazed sycamore tree at top of rod and 18.045 above the zero of the rod. The initial point of measurement is on the left bank, the "deadman" being at station 50. The channel above and below the station is quite straight. The right bank is high and rocky, but the left is subject to overflow in extreme high water. The bed of the stream is of large gravel and bowlders. The observer is Mrs. Alice House. The following discharge measurements were made by J. B. Lippincott and A. Q. Campbell in 1897:

February 13, gage height, 5.18 feet; discharge, 1,021 second-feet.
April 5, gage height, 6.82 feet; discharge, 2,071 second-feet.
June 1, gage height, 10.02 feet; discharge, 8,838 second-feet.
July 15, gage height, 7.17 feet; discharge, 3,313 second-feet.
September 9, gage height, 4.10 feet; discharge, 295 second-feet.
November 1, gage height, 4.57 feet; discharge, 552 second-feet.
December 22, gage height, 4.70 feet; discharge, 515 second-feet.

Daily gage height, in feet, of Kings River at Red Mountain, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.30	9.10	6.00	6.60	9.90	10.20	7.40	5.50	4.30	4.00	4.60	4.90
2	.....	.....	6.02	6.60	9.10	10.40	7.80	5.30	4.30	4.00	4.60	4.90
3	.....	.....	6.03	6.50	9.90	10.20	8.00	5.30	4.40	4.00	4.60	5.00
4	.....	5.90	6.00	6.60	10.50	10.20	7.70	5.30	4.30	3.90	4.50	4.90
5	.....	5.80	5.90	6.80	10.90	10.30	7.50	5.10	4.30	3.90	4.40	4.90
6	.....	.....	7.70	7.50	11.30	10.40	7.40	5.10	4.20	3.90	4.30	4.70
7	.....	.....	8.20	7.20	11.00	10.30	7.30	5.00	4.10	3.90	4.30	4.70
8	.....	.....	6.80	7.50	10.90	10.00	6.70	5.20	4.10	3.90	4.30	9.80
9	.....	.....	6.40	7.90	11.00	10.20	6.60	5.00	4.10	3.80	4.40	6.30
10	.....	5.60	6.40	8.00	11.00	10.20	6.70	5.00	4.00	3.80	4.40	5.70
11	.....	.....	6.20	8.30	11.30	10.00	6.50	4.90	4.10	3.80	4.30	5.30
12	4.30	.....	6.20	8.30	11.40	9.80	7.00	4.90	4.00	3.90	4.30	5.00
13	.....	.....	6.00	9.00	11.40	9.70	7.00	4.80	4.00	4.00	4.30	5.00
14	.....	.....	5.90	9.30	11.60	9.60	7.20	4.80	4.00	4.00	4.40	5.20
15	4.30	.....	5.80	9.60	11.30	9.00	7.20	4.70	4.00	4.60	4.30	5.10
16	.....	.....	5.90	9.70	10.60	8.40	7.20	4.70	4.00	4.00	4.20	4.70
17	.....	.....	6.00	9.90	10.50	7.60	6.80	4.70	3.80	4.30	4.20	4.80
18	.....	.....	5.80	10.10	10.60	7.40	6.50	4.70	3.90	4.30	4.10	4.80
19	4.10	6.30	6.30	9.50	10.90	7.30	6.30	4.80	3.70	4.30	4.10	4.70
20	.....	6.00	6.10	8.80	11.00	7.00	6.20	4.80	3.70	4.30	4.10	4.70
21	.....	5.90	5.90	8.40	11.10	7.00	6.10	4.90	3.80	4.20	6.50	4.70
22	.....	5.70	5.90	8.80	11.60	7.30	6.10	5.10	3.80	4.10	5.10	4.70
23	.....	5.50	5.70	8.30	12.30	7.30	5.90	5.00	3.80	4.10	5.40	4.80
24	4.30	5.50	6.00	8.20	12.40	7.40	6.00	5.00	3.90	4.30	7.00	4.80
25	.....	5.50	6.20	8.40	12.00	7.30	6.00	4.90	3.90	4.50	5.90	4.80
26	.....	5.80	6.80	9.20	11.50	7.30	5.90	4.80	3.80	4.50	5.40	4.60
27	.....	6.00	6.70	9.50	11.40	7.30	5.90	4.70	3.90	4.50	5.00	4.70
28	4.30	6.00	7.80	9.70	11.50	7.20	5.50	4.70	3.90	4.60	5.00	4.60
29	.....	.....	7.20	9.60	11.50	7.10	5.50	4.60	3.90	4.60	4.90	4.60
30	.....	.....	6.90	9.70	11.10	7.20	5.40	4.50	3.90	4.60	4.70	4.60
31	4.70	.....	6.50	.....	11.10	.....	5.40	4.30	.....	4.60	.....	4.60

KINGSBURG STATION ON KINGS RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 393, is located at the Southern Pacific Railway bridge, approximately 1 mile south of Kingsburg, California. The vertical gage, the property of the railway company, is nailed to the south central railroad pier, with the zero 31.66 feet below the top of the rail of the bridge. The channel of the stream at the wagon bridge, 200 feet below the railroad bridge, where discharge measurements were first made, is badly broken by the piers of both bridges. The direction of the flow is oblique to both, and the channel contains shifting sand bars. The right bank is not subject to overflow except in very high water, but the left bank is low. Discharge measurements subsequent to April 7, 1897, were made 2 miles above the railroad bridge at Clark's bridge which crosses the river in one span. The section here is uniform and does not change. The water is very deep and slow. The observer is Alf. Thompson. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

February 11, gage height, 5.58 feet; discharge, 905 second-feet.
April 6, gage height, 5.20 feet, discharge, 825 second-feet.
June 3, gage height, 8.60 feet, discharge, 5,959 second-feet.
July 17, gage height, 5.02 feet; discharge, 503 second-feet.
September 10, gage height, 3.20 feet; discharge, 221 second-feet.
November 3, gage height, 4.84 feet; discharge, 465 second-feet.
December 23, gage height, 4.80 feet; discharge, 522 second-feet.

Daily gage height, in feet, of Kings River at Kingsburg, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.08	5.54	5.63	5.33	8.04	8.83	5.21	4.00	3.17	3.29	5.00	5.04
2	4.00	8.58	6.21	5.79	7.50	8.25	5.37	3.88	3.29	3.33	4.96	5.12
3	3.79	6.63	5.79	5.21	8.08	8.08	5.58	3.75	3.25	3.33	4.83	4.96
4	3.67	6.21	5.92	4.92	8.83	8.12	5.62	3.75	3.25	3.13	4.83	4.92
5	4.08	6.08	5.54	5.08	9.42	8.12	5.50	3.75	3.25	3.08	4.75	4.87
6	4.00	7.13	5.58	5.21	9.58	8.33	5.46	3.66	3.25	3.21	4.70	4.83
7	4.00	6.42	7.58	5.50	9.54	8.37	5.33	3.50	3.25	3.33	4.66	4.75
8	3.67	6.04	6.67	5.75	9.33	8.21	5.12	3.46	3.25	3.50	4.66	4.83
9	3.25	5.88	6.00	5.83	9.17	7.96	4.66	3.50	3.25	3.54	4.37	7.08
10	3.25	5.83	5.92	6.13	9.38	8.00	4.33	3.42	3.17	3.67	4.17	6.08
11	3.17	5.54	5.58	6.54	9.75	7.62	4.54	3.46	3.17	3.67	4.17	5.62
12	3.25	5.33	5.54	6.58	9.71	7.37	4.42	3.50	3.17	3.71	4.17	5.50
13	3.38	5.21	5.46	6.92	9.88	7.42	4.62	3.42	3.00	3.67	4.17	5.50
14	3.92	5.04	5.29	7.33	10.04	7.29	4.79	3.37	3.04	3.75	4.12	5.46
15	4.50	4.92	5.17	7.67	9.83	7.12	5.25	3.25	3.25	4.08	4.08	5.37
16	4.08	4.83	5.00	7.88	10.04	6.92	5.21	3.25	3.25	4.79	4.00	5.29
17	3.88	4.63	5.00	7.88	9.04	6.17	5.04	3.25	3.25	4.62	3.83	5.17
18	3.58	5.75	5.50	8.13	8.79	5.75	4.62	3.21	3.25	4.50	3.75	5.08
19	3.42	5.96	5.67	8.00	8.92	5.54	4.21	3.00	3.25	4.46	3.75	5.08
20	3.42	6.08	5.71	7.54	9.29	5.46	4.08	3.33	3.25	4.50	3.75	4.92
21	3.46	6.00	5.71	6.92	9.75	5.17	3.70	3.33	3.25	4.33	3.75	4.83
22	3.50	5.92	5.38	6.71	10.04	5.04	3.54	3.58	3.37	4.29	6.54	4.75
23	3.50	5.63	4.83	6.54	10.79	5.29	3.29	3.50	3.33	4.33	5.92	4.75
24	3.50	5.42	4.58	6.29	11.33	5.37	3.54	3.25	3.00	4.50	5.75	4.66
25	3.58	5.42	4.58	6.38	10.37	5.46	3.38	3.25	3.04	5.12	6.58	4.83
26	3.50	5.50	4.96	6.71	9.92	5.54	3.50	3.25	3.25	5.08	5.66	4.79
27	3.33	5.50	5.71	7.04	9.54	5.29	3.50	3.96	3.25	5.25	5.46	4.96
28	3.29	5.50	5.46	7.54	9.66	5.25	3.46	3.08	3.33	5.21	5.33	4.96
29	3.58	.....	7.04	7.75	9.70	5.21	3.42	3.25	3.33	5.08	5.12	4.83
30	3.54	.....	6.08	7.83	9.70	5.17	3.50	3.33	3.25	5.00	5.08	4.83
31	4.79	.....	5.50	.....	9.54	.....	3.92	3.17	.....	5.00	.....	4.83

PALMDALE STATION ON LITTLE ROCK CREEK.

This station, as described in the Eighteenth Annual Report, Part IV, page 402, is located about 8 miles southeast of West Palmdale, California, at the headworks of the South Antelope Valley Canal. The creek is diverted through a tunnel into a flume at the headworks, which at the normal stage of the stream will carry all of the water. A gage has been placed in this flume, in which the discharge measurements are made at low stages. During high water a second gaging will be made from the bridge, where the flume crosses the creek, one-half mile below the headworks, and a gage rod will be placed there for that station. The flume is straight. The channel of the stream is crooked and the bed is full of bowlders. The banks are high, and the creek will not leave its present channel at the bridge. The observer is Burt Cole. The following discharge measurements were made in 1897 by J. B. Lippincott and Burt Cole:

February 9, at long flume, gage height, 0.56 foot; discharge, 20 second-feet.
February 9, at headworks flume, gage height, 0.91 foot; discharge, 21 second-feet.
February 9, at long chute, gage height, 0.34 foot; discharge, 21 second-feet.
February 9, at box flume, gage height, 2.00 feet; discharge, 126 second-feet.
March 7, gage height, 1.17 feet; discharge, 26 second-feet.
March 7, gage height, 2.00 feet; discharge, 69 second-feet.
April 7, gage height, 2.80 feet; discharge, 126 second-feet.
April 16, gage height, 0.70 foot; discharge, 14 second-feet.
May 3, gage height, 1.47 feet; discharge, 47 second-feet.
May 15, gage height, 0.45 foot; discharge, 7 second-feet.

Daily gage height, in feet, of Little Rock Creek at Palmdale, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.40	2.10	2.25	2.80	2.05	0.40	0.05	0.00	0.00	0.00	0.40	0.35
2	.30	2.50	2.10	2.80	1.95	.40	.05	.00	.00	.00	.40	.30
3	.25	2.25	2.15	2.80	1.80	.40	.05	.00	.00	.05	.40	.30
4	.20	1.70	2.10	2.80	2.00	.40	.03	.00	.00	.10	.40	.30
5	.30	1.75	2.10	2.80	2.00	.40	.03	.00	.00	.10	.40	.30
6	.30	2.05	2.00	2.80	1.85	.40	.03	.00	.00	.15	.40	.30
7	.30	1.60	2.00	2.80	1.80	.40	.03	.00	.00	.20	.40	.30
8	.30	1.50	1.75	2.80	1.65	.40	.02	.00	.00	.20	.40	.30
9	.32	1.22	1.40	2.50	1.65	.40	.02	.00	.00	.25	.40	.35
10	.35	1.15	1.40	2.60	1.55	.40	.00	.00	.00	.30	.40	.35
11	.45	1.00	1.45	2.70	1.45	.40	.00	.00	.00	.40	.40	.35
12	.48	.80	1.45	2.70	1.40	.40	.00	.00	.00	.40	.40	.35
13	.52	.90	1.40	2.70	1.35	.40	.00	.00	.00	.40	.40	.35
14	.42	.80	1.40	2.70	1.25	.40	.00	.00	.00	.40	.40	.35
15	.50	.80	1.40	2.70	1.25	.40	.00	.00	.00	.40	.40	.35
16	.60	.70	1.40	2.70	1.10	.40	.00	.00	.00	.40	.40	.35
17	.62	.70	1.40	2.70	1.00	.40	.00	.00	.00	.40	.40	.35
18	.65	1.55	1.60	2.70	.90	.40	.00	.00	.00	.40	.40	.35
19	.60	1.35	1.60	2.70	.80	.40	.00	.00	.00	.40	.40	.35
20	.55	1.00	1.90	2.35	.70	.40	.00	.00	.00	.40	.40	.35
21	.65	1.00	1.60	2.45	.70	.40	.00	.00	.00	.40	.40	.35
22	.82	1.00	1.60	2.25	.70	.40	.00	.00	.00	.40	.40	.35
23	.80	.90	1.35	2.25	.70	.40	.00	.00	.00	.40	.40	.35
24	.80	.90	1.45	2.20	.70	.40	.00	.00	.00	.40	.40	.35
25	.80	1.00	1.90	2.30	.65	.40	.00	.00	.00	.40	.40	.35
26	.75	1.15	2.60	2.00	.60	.40	.00	.00	.00	.40	.40	.35
27	.60	1.80	2.35	2.15	.55	.35	.00	.00	.00	.40	.40	.35
28	.60	1.70	2.40	2.25	.55	.30	.00	.00	.00	.40	.40	.35
29	.70	.....	2.70	2.25	.60	.25	.00	.00	.00	.40	.35	.35
30	1.10	.....	2.80	2.20	.55	.15	.00	.00	.00	.40	.35	.35
31	1.35	.....	2.80	.....	.45	.....	.00	.00	.....	.40	.....	.35

AZUSA STATION ON SAN GABRIEL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 405, is located at the mouth of the San Gabriel River canyon, 2 miles northeast of Azusa, California. During the greater portion of the year all the water of the San Gabriel River is diverted into canals and the measurements of discharge are then made at the division box of the Azusa-Duarte canal. The gage rod is vertical and nailed to the inside of the box, with the zero of the rod at the bottom of the flume, or 1.335 feet below the knife edge of the weir. At times, during the winter season, water flows past the diversion points down the river, and in order to measure this amount a gage rod has been placed in the right bank of the river at a point near the division box. A few hundred feet above is a cable, car, and tag-wire for measuring the floods. R. M. Fellows and H. F. Parkinson are the observers. The bench mark to which both rods are referred is a cross in the wooden sill at the head of the lowest Azusa tunnel. It is 7.97 feet above the zero of the river rod. The channel of the river for 200 feet above and below the cable is straight. The banks are not liable to change. The bed of the stream is full of bowlders embedded in sand. June 4 a diversion dam was placed just below the river gage backing the water up above it. Readings on this rod were then discontinued. The rod and cable were moved up the river later in the season.

The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

On the river:

January 10, gage height, 1.28 feet; discharge, 4.5 second-feet.
January 25, gage height, 2.00 feet; discharge, 58 second-feet.
February 1, gage height, 5.10 feet; discharge, 1,725 second-feet.
February 2, gage height, 3.40 feet; discharge, 422 second-feet.
March 12, gage height, 3.30 feet; discharge, 410 second-feet.
April 29, gage height, 2.60 feet; discharge, 162 second-feet.
May 24, gage height, 2.08 feet; discharge, 76 second-feet.
November 13, discharge, 8 second-feet.
November 27, discharge, 3.5 second-feet.

In the Division Box.

January 10, gage height, 2.10 feet; discharge, 22 second-feet.
April 29, gage height, 2.88 feet; discharge, 71 second-feet.
May 24, gage height, 2.98 feet; discharge, 68 second-feet.
June 30, gage height, 2.76 feet; discharge, 56 second-feet.
July 5, gage height, 2.72 feet; discharge, 54 second-feet.
August 7, gage height, 2.33 feet; discharge, 31 second-feet.
September 1, gage height, 2.20 feet; discharge, 24 second-feet.
September 29, gage height, 2.10 feet; discharge, 19 second-feet.
November 13, gage height, —— feet; discharge, 25 second-feet.
November 27, gage height, —— feet; discharge, 33 second-feet.

Daily gage height, in feet, of San Gabriel River at Azusa, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	.....	5.01	3.00	3.10	.....	1.80	17	.....	2.10	3.50	3.05	.....	.....
2	.....	4.00	3.00	3.00	.....	.....	18	2.00	5.00	3.00	3.05	2.20	.....
3	.....	3.00	3.10	3.10	2.50	.....	19	.....	3.90	3.20	3.00	2.15	.....
4	.....	2.90	3.05	3.00	.....	1.80	20	.....	3.60	3.15	2.90	.....	.....
5	1.25	2.55	3.05	3.00	2.50	.....	21	.....	3.20	3.10	2.90	.....	.....
6	1.25	2.60	4.60	3.10	.....	.....	22	2.00	3.00	3.00	2.80	2.95	.....
7	.....	2.50	5.15	3.10	.....	.....	23	2.00	2.95	3.00	2.70	.....	.....
8	.....	2.45	4.30	3.10	2.50	.....	24	.....	2.90	3.00	2.65	2.10	.....
9	.....	2.40	3.80	3.10	.....	.....	25	.....	3.00	3.10	.....	.....	.....
10	1.30	2.35	3.50	3.15	.....	.....	26	.....	3.05	3.10	2.57	.....	.....
11	1.90	2.25	3.45	3.10	.....	.....	27	1.98	3.00	3.10	.....	1.90	.....
12	.....	2.20	3.40	3.15	2.38	.....	28	.....	3.00	3.00	.....	.....	.....
13	.....	2.15	3.30	3.20	.....	.....	29	.....	.....	3.10	.....	1.85	.....
14	.....	2.10	3.20	3.20	.....	.....	30	2.10	.....	3.10	.....	1.80	.....
15	.....	2.10	3.20	3.20	2.25	.....	31	2.05	.....	3.10	.....	.....	.....
16	.....	2.00	3.20	3.07	.....	.....							

WARM SPRINGS STATIONS ON SANTA ANA RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 411, is located 5 miles northeast of Mentone, California, three-fourths of a mile below the headworks of the Santa Ana Canal and opposite the Warm Springs in the canyon. The gage is an inclined timber, the lower end of which has been set under the projecting edge of a large bowlder and fastened to upright posts at its upper end. August 31, 1897, a second gage was placed 1 mile above this location and above the headworks of the Santa Ana Canal. The record as published in this report is for the lower gage. The observer is A. Laird, ditch watchman and water divider on the Bear Valley system. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

January 27, gage height, —— feet; discharge, 44 second-feet.
March 4, gage height, 1.45 feet; discharge, 101 second-feet.
May 3, gage height, 1.50 feet; discharge, 96 second-feet.
May 4, gage height, 1.50 feet; discharge, 98 second-feet.
June 15, gage height, 1.15 feet; discharge, 64 second-feet.
July 5, gage height, 1.20 feet; discharge, 72 second-feet.
July 6, gage height, 1.11 feet; discharge, 60 second-feet.
August 8, gage height, 1.32 feet; discharge, 56 second-feet.
August 31, gage height, 1.35 feet; discharge, 60 second-feet.
September 30, gage height, 1.13 feet; discharge, 43 second-feet.
November 14, gage height, 1.25 feet; discharge, 40 second-feet.

At new station, 1 mile above old one:

August 31, gage height, 1.00 foot; discharge, 78 second-feet.
September 30, gage height, 0.83 foot; discharge, 65 second-feet.
November 14, gage height, 0.35 foot; discharge, 47 second-feet.

Daily gage height, in feet, of Santa Ana River at Warm Springs, California, for 1897.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Oct.	Nov.	Dec.
1	1.25	2.70	1.60	1.60	1.50	1.10	1.15	1.30	1.30	1.15	1.10
2	1.23	2.10	1.60	1.60	1.50	1.05	1.05	1.35	1.17	1.15	1.05
3	1.00	1.85	1.55	1.55	1.50	1.10	1.10	1.35	1.15	1.15	1.05
4	1.00	1.85	1.50	1.60	1.50	1.15	1.15	1.35	1.15	1.15	1.05
5	1.00	1.65	1.45	1.60	1.50	1.10	1.10	1.35	1.20	1.15	1.05
6	.96	1.65	1.60	1.65	1.50	1.05	1.10	1.30	1.25	1.15	1.05
7	.92	1.65	2.50	1.70	1.50	1.05	1.10	1.30	1.23	1.15	1.05
8	.92	1.80	1.65	1.70	1.45	1.05	1.15	1.35	1.30	1.15	1.05
9	.92	1.85	1.65	1.65	1.40	1.05	1.20	1.35	1.23	1.20	1.05
10	.92	1.65	1.60	1.65	1.30	1.10	1.15	1.35	1.12	1.20	1.05
11	1.12	1.50	1.50	1.75	1.30	1.10	1.20	1.35	1.20	1.30	1.05
12	1.10	1.50	1.50	1.75	1.30	1.10	1.20	1.40	1.20	1.30	1.05
13	1.16	1.50	1.50	1.80	1.30	1.15	1.15	1.40	1.23	1.30	1.05
14	1.21	1.40	1.40	1.80	1.30	1.15	1.25	1.40	2.60	1.27	1.05
15	1.37	1.40	1.50	1.75	1.25	1.20	1.15	1.40	1.25	1.25	1.15
16	1.21	1.35	1.60	1.75	1.25	1.20	1.30	1.30	1.15	1.25	1.05
17	1.40	1.40	1.50	1.75	1.20	1.20	1.20	1.30	1.10	1.20	.95
18	1.40	2.90	1.45	1.80	1.15	1.20	1.20	1.30	.90	1.20	1.00
19	1.35	2.10	1.40	1.80	1.10	1.20	1.20	1.30	.90	1.20	1.00
20	1.35	2.05	1.60	1.80	1.10	1.20	1.15	1.35	.90	1.20	.90
21	1.40	1.70	1.45	1.70	1.10	1.20	1.10	1.45	.90	1.17	.80
22	1.40	1.70	1.40	1.65	1.10	1.20	1.15	1.25	.90	1.15	.80
23	1.45	1.65	1.40	1.60	1.10	1.15	1.15	1.15	.90	1.15	.90
24	1.45	1.60	1.30	1.60	1.15	1.15	1.20	1.25	.95	1.15	.90
25	1.45	1.60	1.35	1.60	1.10	1.15	1.20	1.35	.95	1.25	1.00
26	1.45	1.65	1.35	1.60	1.05	1.20	1.25	1.35	1.05	1.15	1.00
27	1.45	1.55	1.40	1.55	1.00	1.20	1.35	1.30	1.05	1.15	1.00
28	1.45	1.55	1.75	1.60	1.00	1.20	1.30	1.30	1.10	1.15	1.00
29	1.45	.....	1.60	1.55	1.00	1.10	1.30	1.35	1.25	1.15	1.00
30	1.50	.....	1.55	1.50	.95	1.15	1.30	1.35	1.25	1.15	1.00
31	1.45	.....	1.60	.....	.95	.....	1.30	1.35	1.25	.....	1.00

[1] No record for September on lower rod.

INDEX TO PAPERS NOS. 15 AND 16.

A.

Page.

Abiquiu, N. Mex., hydrographic work at..... 129
Adams, A. J., work of..... 182, 183, 184
Alabama, gaging stations in 51–57
Alderson, W. Va., hydrographic work at..... 58
Almon, Ga., hydrographic work at..... 43
Alston, S. C., hydrographic work at..... 37
Animas River, measurements of 146
Anschutz, F. H., work of..... 23, 25, 58, 59
Antietam Creek, measurements of 16
Arboles, Colo., hydrographic work at 144–145
Arizona, gaging stations in 147–151
Arkansas River, measurements of ... 117–122, 124
Arkins, Colo., hydrographic work near..... 94
Arnold, Sydney, work of 174, 176, 179
Asheville, N. C., hydrographic work at..... 60
Azusa, Cal., hydrographic work at 194

B.

Babb, Cyrus C., work of..... 22, 117, 135, 136, 137, 141, 165, 171, 172, 173, 174, 175, 176, 177, 178, 180, 181
Battle Creek, Idaho, hydrographic work at... 157
Battle Mountain, Nev., hydrographic work at. 153
Bear Creek, Colo., measurements of 90
Bear River, measurements of..... 157, 159
Beloit, Kans., hydrographic work at 110
Beverly, Kans., hydrographic work at 112
Big Goose Creek, measurements of..... 77
Big Thompson River, measurements of 94
Blacksburg, S. C., hydrographic work at 36
Blacks Fork, measurements of..... 134
Black Warrior River, measurements of 57
Blake, Utah, hydrographic work at 136
Blue River, measurements of..... 115
Boise, Idaho, hydrographic work at..... 168
Boise River, measurements of..... 168
Bond, Fred, work of..... 78
Boulder, Colo., hydrographic work near..... 92
Boulder Creek, measurements of..... 92
Bozeman Creek, measurements of..... 75
Bozeman, Mont., hydrographic work near.... 66, 67, 75
Brash, W. J., work of..... 147
Broad River, Ga., measurements of..... 40
Broad River, S. C., measurements of..... 36–37
Bruneau River, measurements of..... 167
Bryson, N. C., hydrographic work at..... 61
Buchanan, Va., hydrographic work at..... 24
Buffalo, Wyo., hydrographic work at..... 78
Buttes, Ariz., hydrographic work at 147

C.

Page.

Caldwell, H. W., work of..... 12
Calhoun Falls, S. C., hydrographic work at... 39
California, gaging stations in..... 185–195
Calowa River, measurements of..... 184
Campbell, A. Q., work of..... 187, 188, 190, 191, 192, 194, 195
Camp Clarke, Nebr., hydrographic work at... 85
Canton, Ga., hydrographic work at..... 48
Canyon City, Colo., hydrographic work at.... 119
Cape Fear River, measurements of..... 31
Carey, Ga., hydrographic work at..... 41
Carlton, Ga., hydrographic work at..... 40
Carters, Ga., hydrographic work at..... 49
Catawba, N. C., hydrographic work at..... 34
Catawba River, measurements of 34–35
Chama River, measurements of..... 129
Chattahoochee River, measurements of.... 46–47
Chattanooga, Tenn., hydrographic work at .. 64
Chinook, Mont., hydrographic work at 73
Clarksville, Va., hydrographic work at..... 26
Clear Creek, Wyo., measurements of..... 78
Cogswell, F., work of..... 88, 89, 91, 92, 93, 117, 118, 119, 120, 123, 127, 137, 139, 141, 142, 143, 144, 145, 146
Collinston, Utah, hydrographic work at..... 159
Colorado, gaging stations in..... 87–94, 117–123, 127, 137, 139–146
Colorado River, measurements of 151
Colton, A. T., work of 147
Columbus, Nebr., hydrographic work near. 97–98
Coosa River, measurements of..... 51–55
Coosawattee River, measurements of..... 49
Courchesne, T. M., work of..... 132
Crawford, Nebr., hydrographic work near.... 79
Cumberland, Md., hydrographic work at..... 15

D.

Dallis, P. A., work of..... 42
Dan River, measurements of..... 26
Davis, Arthur P., work of 7, 15, 16, 37, 38, 61, 62, 63
Deansbury, Colo., hydrographic work at 87
Delaware River, measurements of.....
Del Norte, Colo., hydrographic work at 127
Denver, Colo., hydrographic work at..... 88
Denver and Rio Grande Railroad, aid by. 137, 140
Deschutes River, measurements of..... 181
Dobson, Adna, work of..... 80, 95, 96, 97, 98, 99, 108
Dolores, Colo., hydrographic work at..... 143
Dolores River, measurements of..... 143

Page.
Dougall, W. G., work of..... 136, 159, 160, 161, 162
Dublin, Ga., hydrographic work at..... 42
Dungeness River, measurements of..... 182
Durango, Colo., hydrographic work at 146

E.

Elkhorn River, measurements of 99
Elko, Nev., hydrographic work at 152
Ellsworth, Kans., hydrographic work at 114
El Paso, Tex., hydrographic work at 132
Elwha River, measurements of 183
Embudo, N. Mex., hydrographic work at.... 128
Emery, Roe, work of.. 65, 66, 67, 68, 69, 71, 73, 74, 75
Engineer Corps, United States, work of. 51, 54, 65
Etowah River, measurements of..... 48

F.

Fall Creek, Colo., hydrographic work at..... 142
Farish, W. A., work of 148, 150
Fayetteville, N. C., hydrographic work at.... 31
Fayette, W. Va., hydrographic work at 59
Firth, Charles, aid by..... 54
Flint River, measurements of..... 45
Follett, W. W., work of..... 132
Forks, Wash., hydrographic work at 184
Fort Crawford, Colo., hydrographic work at.. 139
Fortier, S., work of..... 157, 158, 160
Fort Mill, S. C., hydrographic work near 85
Fort Niobrara, Nebr., hydrographic work near. 80
Frederick, Md., hydrographic work at 20
French Broad River, measurements of 60

G.

Gaffney, S. C., hydrographic work at 36
Gallatin River, measurements of..... 68
Geneva, Utah, hydrographic work at..... 163
Georgia, gaging stations in..... 40–50
Gering, Nebr., hydrographic work at..... 84
Gibbon, Oreg., hydrographic work at..... 180
Gila River, measurements of..... 147
Glasgow, Va., hydrographic work at 23
Golconda, Nev., hydrographic work at 154
Grand Junction, Colo., hydrographic work at..... 137–138, 141
Grand River, Colo., measurements of..... 137
Grandview, Idaho, hydrographic work at 167
Granger, Wyo., hydrographic work at..... 134
Granite, Colo., hydrographic work at..... 117
Great Falls, Mont., hydrographic work near. 72
Greenbrier River, measurements of..... 58
Green River, Wyo., measurements of.... 135–136
Greenriver, Wyo., hydrographic work at..... 135
Grey Bull River, measurements of..... 75
Gunnison River, measurements of 140–141
Gypsum, Colo., hydrographic work at 137

H.

Hall, B. M., work of 39, 41, 42, 43, 44, 45, 46, 47, 48, 51, 57
Hall, Max, work of..... 39, 40, 41, 43, 44, 47, 48, 49, 50, 51, 56, 64
Hall, Olin P., work of 50
Harrisburg, Pa., hydrographic work at..... 8
Harroun, P. E., work of 128, 129, 130, 131, 132
Herndon, Cal., hydrographic work at..... 190

Page.
Hill, J. E., aid by..... 75
Hiwassee River, measurements of 63
Holtsburg, N. C., hydrographic work at..... 32
Hood, O. P., work of..... 115
Hood River, measurements of..... 181
Hooper, Wash., hydrographic work at 172
Hope, L. R., work of..... 87
Humboldt River, measurements of..... 152–155
Humphreys, D. C., work of 17, 23, 24, 58, 59
Hutchinson, Kans., hydrographic work at.... 124

I.

Idaho, gaging stations in 157, 164–171
Iola, Kans., hydrographic work at..... 126

J.

James River, measurements of..... 24
Jefferson River, measurements of 70
Jellys Ferry, Cal., hydrographic work at..... 185
Johnston, C. T., work of... 75, 76, 81, 82, 83, 134, 135
Judson, N. C., hydrographic work at 62
Junction City, Kans., hydrographic work at.. 109

K.

Kansas, gaging stations in 109–126
Kansas River, measurements of..... 116
Kingsburg, Cal., hydrographic work at 192
Kings River, measurements of..... 191–192
Kiona, Wash., hydrographic work at..... 176

L.

Lagrange, Cal., hydrographic work at..... 184
Lambertville, N. J., hydrographic work at.... 7
Laramie River, measurements of 81–82
Laurel, Md., hydrographic work at..... 14
Lawrence, Kans., hydrographic work at..... 116
Liberty, Kans., hydrographic work at..... 125
Lippincott, J. B., work of 185, 187, 188, 190, 191, 192, 193, 194, 195
Little Goose Creek, measurements of..... 77
Little Rock Creek, measurements of..... 193
Little Tennessee River, measurements of 62
Little Wood River, measurements of..... 165
Livingston, Mont., hydrographic work near. 74–75
Lock No. 4, Ala., hydrographic work at 51
Lock No. 5, Ala., hydrographic work at 51
Logan, Mont., hydrographic work at 68
Logan River, measurements of 158
Logan, Utah, hydrographic work at 158
Loup River, measurements of..... 97
Middle River, measurements of 96
North River, measurements of..... 95
Loveland, Colo., hydrographic work near 94
Lovell, Wyo., hydrographic work at..... 76
Lyons, Colo., hydrographic work near..... 93

M.

Macon, Ga., hydrographic work at 44
Madison River, measurements of..... 69–70
Malad River, measurements of..... 165
Malheur River, measurements of..... 169
Manhattan, Kans., hydrographic work at 115
Marshall, Colo., hydrographic work at..... 91
Maryland, gaging stations in..... 12–16, 20–21
Mason's Ranch, Nev., hydrographic work at. 156

Page.
Matthes, G. H., work of 15, 17, 21
McCallo, R. C., jr., work of 57
McCoskey, A. B., work of 79, 84
McDowell, Ariz., hydrographic work at.. 148–150
McDonald, Wash., hydrographic work at 183
Mead, Elwood, work of 75, 76
Meeteetse, Wyo., hydrographic work at..... 75
Middle Creek, Mont., measurements of 67
Middle Loup River, measurements of 96
Milk River, measurements of 73
Millville, W. Va., hydrographic work at..... 19
Mills, F. J., work of 164, 166, 168, 171
Milstead, Ala., hydrographic work at..... 56
Missouri River, measurements of 65
Modesto, Cal., hydrographic work at 189
Molena, Ga., hydrographic work at..... 45
Monocacy River, measurements of..... 20
Montana, gaging stations in..... 65–74
Montgomery, Idaho, hydrographic work at... 165
Moro, Oreg., hydrographic work at..... 181
Morrison, Colo., hydrographic work at..... 90
Murphy, E. C., work of..... 116, 125, 126
Murphy, N. C., hydrographic work at 63
Myers, E. W., work of 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 60, 62, 63

N.

Naches River, measurements of..... 174
Neal, N. C. hydrographic work at..... 28
Nebraska, gaging stations in 79–80, 84–86, 95–99, 107–108
Neosho River, measurements of..... 126
Nepesta, Colo., hydrographic work at..... 121
Neuse River, measurements of 30
Nevada, gaging stations in..... 152–156
New Jersey, gaging station in..... 7
New Mexico, gaging stations in..... 128–131
New River, measurements of 59
Nickerson, G. H., work of.... 164, 165, 166, 169, 170
Niles, Kans., hydrographic work at 111
Niobrara River, measurements of 80
Norfolk, Nebr., hydrographic work near 99
North Carolina, gaging stations in ... 28–34, 60–63
North Loup River, measurements of..... 95
North Platte River, measurements of..... 83–85
North River, James, measurements of..... 23
North River, Shenandoah, measurements of.. 17
Norwood, N. C., hydrographic work at 33
North Yakima, Wash., hydrographic work at. 174

O.

Oakdale, Cal., hydrographic work at 187
Oakdale, Ga., hydrographic work at..... 46
Ocmulgee River, measurements of..... 44
Oconee River, measurements of 41–42
Octoraro Creek, Md., measurements of 12
Ogden River, measurements of..... 160
Ogden, Utah, hydrographic work at..... 160
Oostanaula River, measurements of..... 50
Orchard, Colo., hydrographic work at 89
Oreana, Nev., hydrographic work at 155
Oregon, gaging stations in 169, 180–181
Orin Junction, Wyo., hydrographic work at.. 83

P.

Palmdale, Cal., hydrographic work at 193
Palouse River, measurements of..... 172
Patapsco River, measurements of..... 13
Patuxent River, measurements of..... 14
Paul, E. G., work of 7, 8, 13, 14, 15, 19, 20, 21
Payette, Idaho, hydrographic work at..... 170
Payette River, measurements of..... 170
Peedee River, measurements of 33
Pennsylvania, gaging station in 8
Phœnix, Ariz., hydrographic work near.. 148, 150
Piedra River, measurements of..... 145
Platte River, measurements of 98
Pocatello, Idaho, hydrographic work at 164
Point of Rocks, Md., hydrographic work at .. 21
Port Angeles, hydrographic work near .. 182–183
Portneuf River, measurements of 164
Port Republic, Va., hydrographic work at ... 17
Potomac River, measurements of..... 15, 21
Preston, P. J., work of..... 121, 122
Price, Capt. Philip M., aid by 54
Provo River, measurements of..... 162
Provo, Utah, hydrographic work at 162
Pueblo, Colo., hydrographic work at 120
Purgatoire River, measurements of 123

Q.

Quillayute, Wash., hydrographic work at.... 184

R.

Redbluff, Cal., hydrographic work at..... 185
Redbluff, Mont., hydrographic work near.... 69
Red Mountain, Cal., hydrographic work at... 191
Republican River, measurements of 107–109
Resaca, Ga., hydrographic work at 50
Rio Grande, measurements of..... 127–132
Rio Grande, N. Mex., hydrographic work at.. 130
Riverside, Ala., hydrographic work at..... 51
Roanoke River, measurements of 25, 28
Roanoke, Va., hydrographic work at..... 25
Rock Creek, measurements of..... 22
Rock Hill, S. C., hydrographic work near.... 35
Rocky Creek, Mont., measurements of..... 75
Rocky Ford, Colo., hydrographic work at.... 122
Roubideau, Colo., hydrographic work at..... 140
Rowlandsville, Md., hydrographic work at... 12
Russell, W. G., work of..... 109, 110, 111, 112, 113, 114, 124

S.

Sacramento River, measurements of 185
Saleaville, Mont., hydrographic work at 66
Salida, Colo., hydrographic work at 118
Salina, Kans., hydrographic work at..... 113
Saline River, measurements of..... 112–113
Salisbury, N. C., hydrographic work at..... 32
Salt River, measurements of 148
Saluda River, measurements of 38
Sanford, Capt. J. C., aid by..... 65
San Gabriel River, measurements of 194
San Joaquin River, measurements of..... 190
San Juan River, measurements of..... 144
San Marcial, N. Mex., hydrographic work at . 131
San Miguel River, measurements of..... 142
Santa Ana River, measurements of..... 195
Sappington, Mont., hydrographic work at.... 70
Savannah River, measurements of..... 39
Seguin, Wash., hydrographic work at..... 182

Page.
Selah, Wash., hydrographic work at 173
Selma, N. C., hydrographic work at 30
Sharpsburg, Md., hydrographic work at..... 16
Shenandoah River, measurements of..... 19
Sheridan, Wyo., hydrographic work at..... 77
Shields River, measurements of..... 75
Shoshone, Colo., hydrographic work at..... 137
Shoshone River, measurements of..... 76
Smoky Hill River, measurements of..... 114
Snake River, measurements of 165
Solduck River, measurements of 184
Solomon River, measurements of..... 110–111
South Boulder Creek, measurements of..... 91
South Carolina, gaging stations in 35–30
South Fork, Broad River, measurements of .. 40
South Fork, Humboldt River, measurements of 156
South Platte River, measurements of 87–89
South River, Shenandoah, measurements of .. 17
Spokane River, measurements of..... 177
Spokane, Wash., hydrographic work at 177
Stanislaus River, measurements of..... 187
Staunton River, measurements of..... 26
Stout, O. V. P., work of..... 79, 80, 84, 85, 95, 96, 97, 98, 99, 108
St. Paul, Nebr., hydrographic work near... 95, 96
St. Vrain Creek, measurements of..... 93
Sumner, R. S., work of..... 90, 94
Sun River, measurements of..... 72
Superior, Nebr., hydrographic work at..... 107
Susquehanna River, measurements of..... 8

T.

Tallapoosa River, measurements of..... 56
Tarboro, N. C., hydrographic work at..... 29
Tar River, measurements of..... 29
Taylor, L. H., work of..... 152, 153, 154, 155, 156
Tennessee, gaging station in..... 64
Tennessee River, measurements of..... 64
Texas, gaging station in..... 132
Threeforks, Mont., hydrographic work at.... 70
Toponis, Idaho, hydrographic work at..... 165
Townsend, Mont., hydrographic work at..... 65
Trinidad, Colo., hydrographic work at..... 123
Tuckaseegee River, measurements of..... 61
Tuckers, Oreg., hydrographic work at..... 181
Tuolumne River, measurements of..... 188, 189
Tuscaloosa, Ala., hydrographic work at 57

U.

Uinta, Utah, hydrographic work at..... 161
Umatilla River, measurements of..... 180
Uncompahgre River, measurements of..... 139
Union Gap, Wash., hydrographic work at.... 175
Utah, gaging stations in 136, 158–163
Utah Lake, gage heights of 163
Uva, Wyo., hydrographic work at..... 82

V.

Valentine, Nebr., hydrographic work near.... 80
Vale, Oreg., hydrographic work at..... 169
Verde River, measurements of 150
Verdigris River, measurements of..... 125
Vincent, S. R., work of 115
Virginia, gaging stations in 17, 23–26

W.

Wallawalla River, measurements of..... 179
Warm Springs, Cal., hydrographic work at .. 195
Washington, D. C., hydrographic work at ... 22
Washington, gaging stations in .. 172–179, 182–184
Waterloo, S. C., hydrographic work at..... 38
Weather Bureau, observations by 42
Weber River, measurements of..... 161
West Gallatin River, measurements of..... 66
Weiser, Idaho, hydrographic work at 171
Weiser River, measurements of 171
Wenatchee River, measurements of..... 178
Wenatchee, Wash., hydrographic work at.... 178
West Point, Ga., hydrographic work at 47
West Virginia, gaging stations in 19, 58, 59
Wetumpka, Ala., hydrographic work at..... 54
White River, measurements of..... 79
Whitewater, Colo., hydrographic work at 140
Whitman, Wash., hydrographic work at 179
Wiley, A. J., work of..... 167
Woodbury, Ga., hydrographic work at 45
Wood (Little) River, measurements of 165
Woods Landing, Wyo., hydrographic work at. 81
Woodstock, Md., hydrographic work at 13
Wyoming, gaging stations in. 75–78, 81–83, 134–135

Y.

Yadkin River, measurements of..... 32–33
Yakima River, measurements of 173–176
Yellow River, measurements of..... 43
Yellowstone River, measurements of..... 74
Yuma, Ariz., hydrographic work at 151

Z.

Zoological Park, National, Washington, D. C., hydrographic work in..... 22

O

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 17

IRRIGATION NEAR BAKERSFIELD, CALIFORNIA.—GRUNSKY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; and "Irrigation in India," by Herbert M. Wilson. Illustrated by 91 plates and 126 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 28, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American engineering," and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; and "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 18 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell; 1894; quarto, 253 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 507 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; and "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 17

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

IRRIGATION NEAR BAKERSFIELD, CALIFORNIA

BY

CARL EWALD GRUNSKY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

CONTENTS.

	Page.
Letter of transmittal	11
Introduction	13
San Joaquin Valley	15
Water appropriation and irrigation districts	19
Kraft irrigation district	23
Orland South Side irrigation district	23
Central irrigation district	23
Colusa irrigation district	23
College City irrigation district (proposed)	23
Browns Valley irrigation district	23
Modesto irrigation district	24
Turlock irrigation district	24
Madera irrigation district	24
Selma irrigation district	24
Alta irrigation district	24
Tulare irrigation district	24
Tule River irrigation district	25
Tipton irrigation district	25
Poso irrigation district	25
Kern and Tulare irrigation district	25
Huron irrigation district	25
Sunset irrigation district	25
Methods of irrigation	26
Wild flooding	26
Flooding in contour checks	27
Flooding in rectangular checks, not level	29
Flooding in level checks	30
Flooding between parallel levees	31
Furrow irrigation	32
Furrow irrigation of cereals	32
Furrow irrigation of permanent cultures	32
Furrow irrigation in level checks	33
Furrow irrigation of vegetables	33
Irrigation by filling subsoils with water	33
Subirrigation, or irrigation from subsurface conduits	35
Kern River	37
Hydrography	37
Soils and rainfall	41
Canals and ditches	42
Rio Bravo Ranch canals	42
Kern Island Canal	43
Old South Fork	46
Farmers Canal	47
Panama Slough	47
Castro Ditch	48
Fisher & Abley Ditch	48

Kern River—Continued.
Canals and ditches—Continued. Page.
Stine Canal 48
Anderson Canal 48
Gates Canal 49
Buena Vista Canal 49
James Canal 49
Plunkett Ditch 50
Meacham Canal 50
Wilson Canal 50
Henley and Frazier ditches 50
Beardsley Canal 50
McCaffery Ditch 51
McCord Canal 51
Calloway Canal 51
Emery Ditch 55
Jones & Tuckey Ditch 56
Railroad Canal 56
Wible Canal 56
Goose Lake Canal 56
Pioneer Canal 57
Edwards Ditch 58
James & Dixon Canal 58
Johnson Canal 59
Ashe Ditch 60
May Ditch 60
Joice Canal 60
Dixon Canal 61
Kern Valley Water Company's canals 61
Kern and Tulare irrigation district 63
Water supply, distribution, and measurement 64
Methods of irrigating and duty of water 66
Irrigation from Poso Creek 75
Poso irrigation district 75
Irrigation from Deer Creek 76
Wingfield Ditch 76
Carothers Ditch 76
Deer Creek Consolidated Ditch (Sausalito Ditch) 76
Tule River 78
Hydrography 78
Canals and ditches 78
South Tule River Ditch 78
Wilcox Ditch 79
Plano Ditch 79
Vandalia Ditch 79
Rose Ditch 79
Mitchell, Springer & Rose Ditch 79
South Side Tule River Canal 79
Fine Ditch 80
Callison Slough (Woods Central Ditch) 81
Old English Ditch 81
Stockton Ditch 81
Ball & Harris Ditch 82
Empire Ditch 82
Woodville Ditch 82

Tule River—Continued.
Canals and ditches—Continued. Page.
Tipton Ditch ... 82
Janes Ditch ... 83
Lone Oak Slough ... 83
Hively Ditch ... 83
Creech Ditch ... 83
Rogers Lower Ditch ... 83
Fancher Ditch ... 83
Finney Ditch ... 83
Swall Ditch ... 83
Gully Ditch ... 83
Swall & Wessling Ditch ... 84
Great American Ditch ... 84
Pleasant Valley Ditch ... 84
Pioneer Canal ... 84
Traylor Ditch ... 86
Porter Slough ... 86
Hockett Ditch ... 87
Wallace Ditch ... 87
McGee, Putnam & Caldwell Ditch ... 87
Gilliam Ditch ... 87
Hubbs & Miner Ditch ... 87
Fulweiler and Hunsaker ditches ... 88
Pletts Ditch ... 88
Thomas Ditch ... 88
Elrod Ditch ... 88
Ray & Brown Ditch ... 88
M. M. Burnett Ditch ... 88
Bond Ditch ... 89
Rogers Upper Ditch ... 89
Rogers Middle Ditch ... 89
Klein Ditch ... 89
Lamarsna Ditch ... 89
Bacigalupi Ditch ... 89
Bacigalupi & Creighton Canal ... 89
Tulare Lake Canal ... 90
Tule River irrigation district ... 90
Tipton irrigation district ... 91
Methods of irrigation ... 92
Pump irrigation at Lindsay ... 94

ILLUSTRATIONS.

		Page.
PLATE I.	Principal rivers of California	16
II.	Flume across St. Johns Channel, Tulare irrigation district	24
III.	Irrigation by checks in San Joaquin Valley	28
IV.	*A*, Furrow irrigation of vines; *B*, Furrow irrigation of orchard	32
V.	Furrow irrigation of grove	34
VI.	Kern River delta	36
VII.	Kern River: *A*, Looking downstream from canyon; *B*, Two miles below canyon, looking upstream	40
VIII.	Head of Kern Island Canal: *A*, Looking upstream; *B*, Looking downstream	42
IX.	Kern Island Canal regulator and waste gate: *A*, Looking upstream; *B*, Looking downstream	44
X.	*A*, Check weir or drop on Kern Island Canal; *B*, Kern River at head of South Fork	46
XI.	Weir and regulator, head of Calloway Canal	52
XII.	*A*, Calloway Canal; *B*, Irrigating alfalfa in contour checks	54
XIII.	*A*, Pioneer Canal weir; *B*, Pioneer Canal	56
XIV.	*A*, Head flume, Poso irrigation district; *B*, Flume, Poso irrigation district	76
XV.	Map showing canals from Tule and Kaweah rivers	78
XVI.	*A*, Regulator and waste way of South Side Tule River Canal; *B*, Regulator of Pioneer Canal	80
FIG. 1.	Tulare Lake, near mouth of Mussel Slough, 1882	17
2.	Wild flooding	27
3.	Flooding in contour checks	28
4.	Flooding in rectangular checks, not level	30
5.	Irrigation by filling subsoils with water, Mussel Slough country	34
6.	Discharge of Kern River, California, 1894–95	38
7.	Head of Kern Island Canal	46
8.	Head of Calloway Canal	52
9.	Plan of head gate of Calloway Canal	54
10.	Section of head gate of Calloway Canal	55
11.	Section of Pioneer Canal regulator	57
12.	Head of James & Dixon Canal	58
13.	Head of Kern Valley Water Company's canals	62
14.	South Side Tule River Canal	80
15.	Head of Callison Slough and English Ditch	81
16.	Head of Pioneer Canal	84

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, July 1, 1898.

SIR: I have the honor to transmit herewith a manuscript entitled Irrigation near Bakersfield, California, prepared by Mr. C. E. Grunsky, and to recommend that it be published in the series of pamphlets on Water Supply and Irrigation. This paper is the first of three relating to San Joaquin Valley, the others being entitled, respectively, Irrigation near Fresno, California (No. 18 of the series), and Irrigation near Merced, California (No. 19 of the series), these titles being somewhat arbitrarily given to indicate the relative geographic position of the areas described. These papers taken collectively are intended to exhibit the character of the development of irrigation in the southern part of the great valley of California, and to give the methods there employed and the results of the experience acquired through many years.

In this, the first paper, some space has been devoted to a general description of San Joaquin Valley as a whole, and of the irrigation districts which have been organized within it, the history of these being briefly outlined. There is also added a description of the methods of irrigation commonly employed, as this has especial interest in connection with the more detailed statements regarding the individual canals and ditches. Following these more general matters Kern River is taken up, its drainage basin is discussed, and each of the numerous systems of water supply depending upon the river is described at some length. Then the creeks lying to the north, Poso and Deer, are decribed, as well as Tule River.

Although a relatively high degree of development of irrigation has been reached in this part of the arid region, yet the results are far below the possibilities. By means of better methods of water conservation and distribution, and more effective modes of intensive agriculture, the population and wealth of San Joaquin Valley may be almost indefinitely increased. A full discussion, therefore, of this interesting area has value not only as showing what may be, to a certain extent, accomplished elsewhere, but also as illustrating the fact that great progress can still be made in this area.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

HON. CHARLES D. WALCOTT,
Director United States Geological Survey.

IRRIGATION NEAR BAKERSFIELD, CALIFORNIA.

By C. E. GRUNSKY.

INTRODUCTION.

The historical and descriptive treatment of irrigation in San Joaquin Valley as here presented is based largely upon information collected by the State engineering department of California ten years ago. That department ceased to exist in independent form in 1888. Its work was to be completed by the State mineralogist, who during the next two years was ex officio State engineer, and it was expected that a final report would be published, covering irrigation in central portions of the State, to supplement the two volumes already issued.[1] But the third volume of the final report has not appeared, and much of the collected material has been lost or is in unserviceable form, and none of it is conveniently accessible. Under these circumstances the writer, who, as chief assistant State engineer from 1882 to 1887, had charge of the collection of irrigation data in the field now under consideration, and of its preliminary arrangement for publication, believes it timely to give to the public at least such benefit as may result from a delayed publication of a portion of the collected information. To this end use has been made of what is left of official records, notebooks, sketches, and fragmentary manuscript (principally of the writer's own preparation), taking therefrom and grouping whatever seemed of sufficient importance to justify publication.

The facts obtained from this source have been supplemented by the results of subsequent personal experience in the field, and by accounts of irrigation works and of experience obtained from persons of local prominence, as well as by information secured on a special trip through the region under discussion, made in the spring of 1897.

It remains to be said that portions of the river descriptions and kindred matter have been taken from the report of the Examining Commission on Rivers and Harbors,[2] frequently without credit, as the writer was a member of that commission and author of its descriptive chapters.

[1] Irrigation Development, History, Customs, Laws, etc., in France, Italy, and Spain, by Wm. Ham. Hall, C. E., State Engineer, Sacramento, California, 1886; and Irrigation in California (Southern), Part 2 of Report of Wm. Ham. Hall, C. E., State Engineer of California, 1888.

[2] Report Examining Commission on Rivers and Harbors to the Governor of California; C. F. Reed, C. E. Grunsky, J. J. Crawford, commissioners; 1890.

It will be made apparent in these papers that irrigation development has been most rapid in those sections of the valley where rainfall is less than 10 inches a year and where water diversion from the streams is readily accomplished. There has been comparatively little irrigation in the great central valley northward from Merced River. This is due primarily to the greater natural fertility of the soils, resulting from more rainfall than in the upper or southern portions of the valley, but also to the fact that the principal rivers are considerably depressed below the general upland level, making the diversion of water for upland irrigation often difficult and always expensive. Vineyards and orchards in the lower portion of San Joaquin Valley and throughout Sacramento Valley yield fairly well without irrigation, and the standard crop, wheat, is rarely a complete failure. Protests have therefore at times been loud and emphatic against attempts to make water for irrigation available at general expense in this part of the great central valley of the State. Notwithstanding the active opposition which becomes manifest whenever the construction of comprehensive irrigation systems, such as would compel a modification of the present use of lands, is suggested, the spirit of unrest, discontent, and a desire to change conditions preponderates in many sections of the northern portion of the great central valley. This was demonstrated when opportunity was afforded to organize irrigation districts under the Wright law ten years ago. Seven out of eight districts proposed to the northward of Merced River were speedily organized. This desire to change from dry farming to the more intense cultivation of the soil made possible by irrigation is evidenced, too, by the success of a number of small irrigation works in and adjacent to Sacramento Valley. Among these are the irrigation ditches from Cache Creek, near Woodland, Moore Canal, Capay Ditch, and Adams Ditch. Thermalito, Palermo, and Orangevale may be cited as localities where the growth of citrus fruits is stimulated by the use of water. There is some irrigation from Stony Creek. Deer Creek supplies water for the great vineyard at Vina. Putah Creek is drawn upon for pump irrigation of a number of orchards and vineyards, and both stream and wind assist in raising ground water to the surface near Florin for the irrigation of orchards, vineyards, and gardens. It is not within the scope of this paper, however, to enumerate or describe the irrigation works of Sacramento Valley, and they are referred to merely as illustrating the gradual growth of sentiment in favor of the irrigated farm. The backset which irrigation has received by the unsatisfactory operation of the irrigation-district law will, it is hoped, be only a temporary check of healthful development under extensive systems of canals that should make much of the water of our best rivers, now flowing unused to the sea, do duty as an aid to agriculture.

The author desires to express his appreciation of the many courtesies extended to him in all parts of the valley in the work of collecting data,

and to thank those who have kindly contributed their knowledge of facts or have otherwise aided him or contributed material for this publication.

SAN JOAQUIN VALLEY.

San Joaquin Valley is the southern and larger portion of California's great central valley which lies between the Sierra Nevada on the east and the Coast Range on the west. Its length, measured along the axis of the valley, from near Stockton at its lower end to the base of the Tejon Mountains at its upper end, is 250 miles. The average breadth of the valley is over 40 miles. It is naturally divided into an east-side plain and a west-side plain, which slope with remarkable uniformity and smoothness of surface from the base of the hills upon either side toward the valley trough. Of these plains, that upon the east side of the valley, at the base of the Sierra Nevada, is by far the more extensive and the more important.

In their original condition the uplands of the valley were almost treeless. A few groves of oaks, some of considerable extent, were confined to the lands watered by Calaveras and Mokelumne rivers and lesser streams near Stockton; to the black land near Merced, principally to that watered by Bear and Mariposa creeks; and to the deltas of Kings, Kaweah, and Tule rivers. Some timber, too, was found on the river bottoms and on the submersible plain near the trough of the valley. Except where cottonwoods, willows, and occasional oaks or sycamores mark the course of the principal west-side creeks, all the unirrigated lands of the west-side plain and the abutting hills of the Coast Range are bare of trees.

The area of San Joaquin Valley is 11,500 square miles, which may be classified as follows: East-side plain, 7,700 square miles; west-side plain, 1,850 square miles; lands covered with water and lands subject to occasional inundation, about 1,950 square miles, of which 300 to over 900 square miles, according to the stage of Tulare Lake, are lake surfaces.

The mountain watershed tributary to the valley, including Cosumnes River, is 20,400 square miles in extent, of which less than one-fifth lies on the west, in the Coast Range, more than four-fifths being to the east, in the Sierra Nevada. Large rivers of perennial flow enter the valley from the east and cross the broad east-side plain, but on the west the numerous small creeks and gulches have no summer flow, and their channels are lost before they reach the main valley drain.

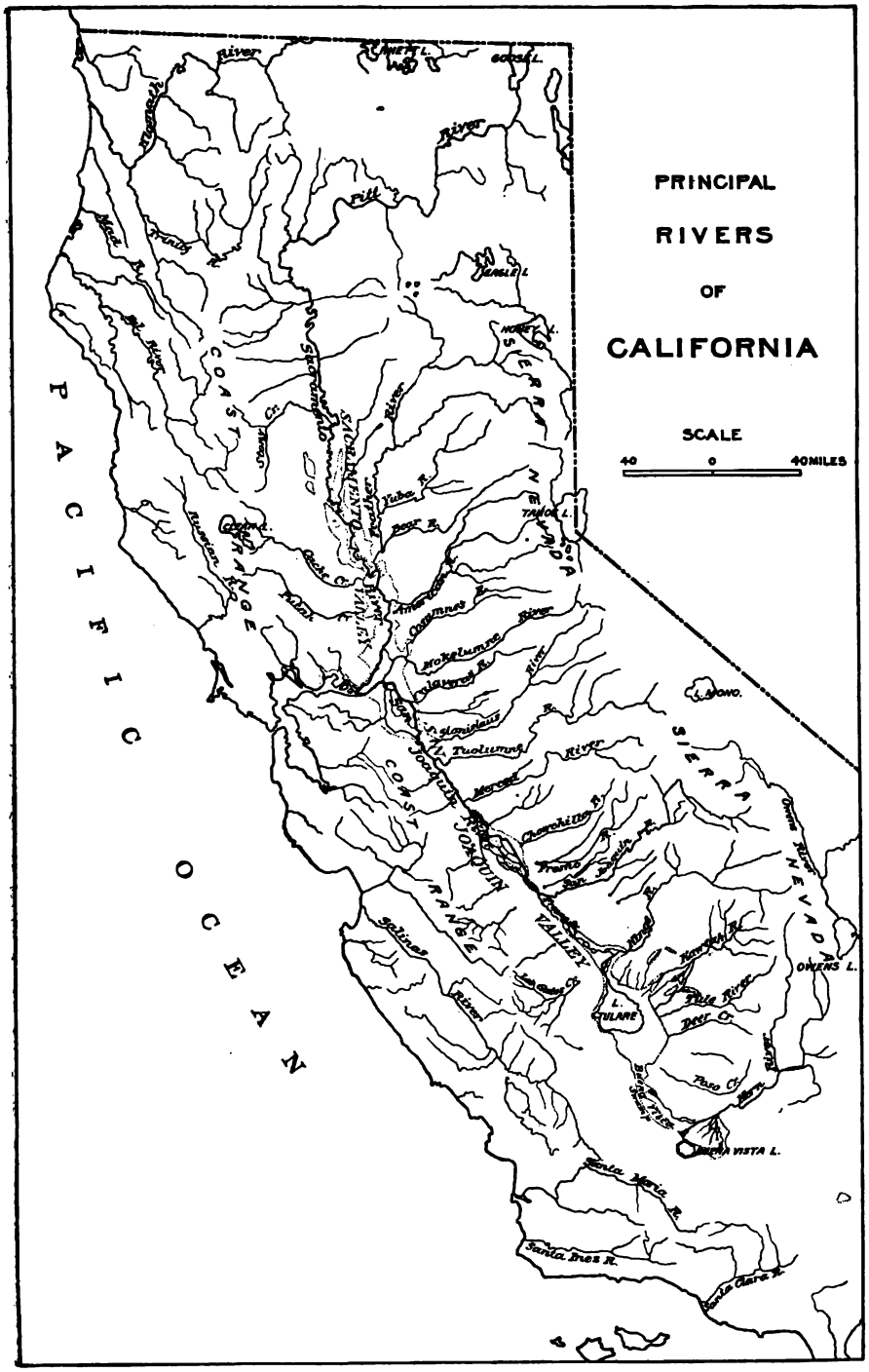
The valley may be considered as again divided into three portions by low, flat ridges built of silt deposits made by two of the principal east-side rivers, Kern River and Kings River, but the lines of demarcation are not features of any prominence. In both cases there has been a gradual pushing forward of the river deltas until basins or depressions

have been formed above the crest line of each, thus giving rise to the Kern and Buena Vista lake basins in the one case and to the Tulare Lake basin in the other.

The former of these basins has never been one of sufficient capacity to prevent the annual outflow of Kern River waters toward the north by way of Buena Vista Swamp into Tulare Lake. The latter, however, repeatedly and for many years at a time, even before there was any diversion of water from tributary rivers for irrigation, has been so insufficiently supplied with water that it failed to overflow. During such periods the entire drainage basin above Tulare Lake, including ordinarily a portion of the flow of Kings River, is not tributary to San Joaquin River, whose watershed area is then reduced to about 19,000 square miles, of which about 7,500 square miles are valley lands, from which there is ordinarily little or no run-off.

Tulare Lake has frequently been under discussion as a source of water supply for irrigation. The following facts with reference to the fluctuations of its water surface will be of interest in connection with its availability for this purpose: In 1853, after several wet seasons, the lake was full, though probably not so high as subsequently, in 1862 or in 1868. From 1853 until 1861 there was a gradual subsidence of the low-water stage of the lake. The rate at which this occurred can not now be determined. In the fall of 1861 the water surface of the lake was at the elevation 204 feet above sea level (low water of Suisun Bay), if the testimony of residents at the lake at that time, in reference to the rise of water the following winter, can be relied upon. The unusually heavy rainfall of the winter of 1861–62 caused the lake to rise to the highest known stage—220 feet. Its area was increased from about 300 to about 800 square miles, and 300 billion cubic feet, or 6,885,000 acre-feet, of water were added to its contents. It continued to overflow at least until the spring of 1863, but then rapidly fell to about 11 or 12 feet below its highest stage, which was its condition in the fall of 1867. The inflow of water during the wet winter of 1867–68 again brought the lake nearly, if not quite, to the high-water stage of 1861–62.

The water surface fluctuated between 211 and 217 feet in the years 1872 to 1876, then receded rapidly to the lowest known stage—192 feet—in November, 1883. From that time to this the lake has not received sufficient water to cause it to overflow. It is generally believed that the diversion of water for irrigation purposes from Kern, Tule, Kaweah, and Kings rivers has been the cause of the decrease of water volume in the lake, but this is not true. Although such diversion must produce some effect on the lake, the evidence that protracted low stages preceded the low stage of 1883 is conclusive. On the northeastern shore of the lake, close by the mouth of Mussel Slough, there is a group of tree stumps at an elevation of about 200 feet. These were found at the water's edge in 1882. They presented the appearance of having been broken off at a height of 3 to 4 feet above ground. They were


PRINCIPAL
RIVERS
OF
CALIFORNIA
SCALE
40 0 40 MILES
PACIFIC OCEAN
COAST RANGE
SIERRA NEVADA
SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
COAST RANGE
SIERRA NEVADA
Pit River
Klamath River
Shasta L.
Goose L.
Mount Shasta
Sacramento River
Feather River
Yuba R.
Bear R.
Trinity River
Trinity R.
Eel River
Mad River
Redwood Creek
Klamath R.
Salmon River
Scott River
Scott R.
Shasta R.
Cottonwood Creek
Cache Creek
Putah Creek
Clear Lake
Honcut Creek
Yuba River
Bear River
Truckee R.
Tahoe L.
Carson River
Walker L.
Mono L.
Cosumnes R.
Mokelumne River
Mokelumne R.
Calaveras R.
San Joaquin R.
Stanislaus R.
Tuolumne River
Merced R.
Chowchilla R.
Fresno R.
San Joaquin River
Kings River
Kings R.
Owens River
Owens L.
Kern River
Kern R.
Tule River
Deer Cr.
Poso Cr.
Buena Vista L.
Tulare L.
Santa Maria R.
Santa Ynez R.
Santa Clara R.
Salinas River
San Luis Cr.

well preserved and must have been under water for nearly thirty years succeeding the high stage of the lake of 1853. These stumps are a remnant of a grove of willow trees, 100 or more, some of which had grown to a diameter of 4 feet. It would not have been possible for these trees to attain such growth if the lake had not been at a low stage for many years in succession at some time preceding 1853. Moreover, Indian tradition is said to indicate a time when the lake was contracted to two ponds, between which a passage from the east to the west side of the valley was possible.

The lowest portion of San Joaquin Valley is but slightly elevated above sea level. The elevation of the surface of the ground is from 10 to 20 feet along the eastern margin of the main body of submersible land in the lower end of the valley. Thence the trough of the valley south-

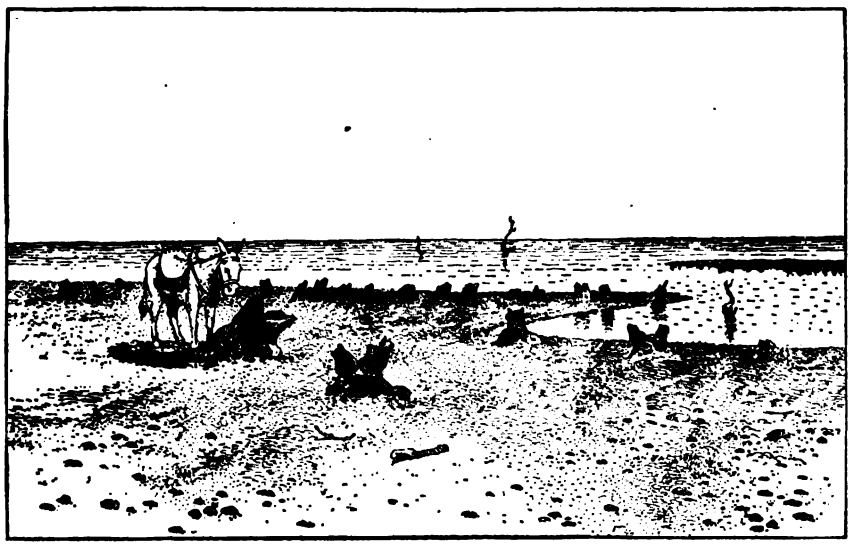


FIG. 1.—Tulare Lake, near mouth of Mussel Slough, 1882.

eastward gradually rises to 214 feet on the flat saddle below Tulare Lake. The elevation of the lowest point in the bottom of Tulare Lake is about 175 feet; and thence there is a rise of about 120 feet to the outfall point of Buena Vista Lake. This lake and Kern Lake occupy the lowest portions of the depression above the Kern River ridge, and their beds are at the elevation of 285 feet.

The eastern edge of the valley rises from an elevation of 110 feet, opposite Stockton, to 500 feet southeastward from Bakersfield. The slope of the east-side plain is from the hills toward the valley trough at the rate of 5 to 10 feet a mile; that of the west-side plain is somewhat greater. Except for the bad-land or alkali strip, of variable width, which flanks the submersible lands of the valley, the entire valley may be considered as well adapted for irrigation so far as soils and physical conditions are concerned.

The Division of Hydrography of the United States Geological Survey has maintained a number of gaging stations in San Joaquin Valley, and has published some of the results.[1]

The important streams which flow into San Joaquin Valley are all Sierra Nevada streams. They appear in small capital letters in the following list of rivers and creeks which are tributary to the valley:

	Area drained, in square miles.
From Tejon Mountains:	
Tejon Creek	64
Tecuya Creek	40
Arroyo Plata	32
San Emidio Creek	69
From the Sierra Nevada:	
Caliente Creek	423
KERN RIVER	2,345
Poso Creek	289
White River	90
Deer Creek	110
TULE RIVER	437
KAWEAH RIVER	619
KINGS RIVER	1,742
SAN JOAQUIN RIVER	1,637
Fresno River	272
Chowchilla River	268
Mariposa Creek	122
Bear Creek	166
MERCED RIVER	1,076
TUOLUMNE RIVER	1,501
STANISLAUS RIVER	1,051
Calaveras River	491
MOKELUMNE RIVER	657
Dry Creek	283
COSUMNES RIVER	580
From the Coast Range:	
Los Gatos Creek	441
Cantua Creek	52
Big Panoche Creek	289
Little Panoche Creek	106
Arroyo Ortigalitos	64
Los Banos Creek	151
San Luis Creek	88
Romero Creek	24
Quinto Creek	29
Las Garzas Creek	57
Orestimba Creek	142
Arroyo de la Puerta	77
Arroyo de los Piedras	20
Hospital Creek	30
Corral Hollow Creek	73
Marsh Creek	54

[1] Twelfth Ann. Rept. U. S. Geol. Survey, Part II, 1891, pp. 316–323, Pls. LXXX–LXXXVIII; Bulletin No. 131, 1895, pp. 78–86; Bulletin No. 140, 1896, pp. 256–314; Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, 1897, pp. 371–396; Water-Supply and Irrigation Paper No. 11, 1897, pp. 90–92; Water-Supply and Irrigation Paper No. 16, 1898, pp. 187–192.

WATER APPROPRIATION AND IRRIGATION DISTRICTS.

It is provided in the constitution of the State of California adopted in 1878 that "the use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution," is a public use, subject to regulation and control by the State, and that water rates are to be fixed annually by the governing bodies of counties and municipalities.

The civil code of the State says: "The right to the use of running water flowing in a river or stream or down a canyon or ravine may be acquired by appropriation." But this right ceases when the water ceases to be applied to some useful or beneficial purpose. As between appropriators, the one first in time is the first in right.

The method of making an appropriation and of giving notice of the water claim is thus prescribed:

> . . . person desiring to appropriate water must post a notice, in writing, in a conspicuous place, at the point of intended diversion, stating therein: (1) That he claims the water there flowing to the extent of (giving the number) inches, measured under a four-inch pressure; (2) the purposes for which he claims it, and the place of intended use; (3) the means by which he intends to divert it, and the size of the flume, ditch, pipe, or aqueduct in which he intends to divert it. A copy of the notice must, within ten days after it is posted, be recorded in the office of the recorder of the county in which it is posted.

But the mere posting and recording of this claim to water confers no right upon the appropriator unless, within sixty days after the notice is posted, the construction of works is commenced and diligently prosecuted to completion. In that event, and in that only, are rights acquired, which then relate back to the time the notice was posted. Moreover, the water right secured under the notice and by construction of works should not be considered to be that defined in the notice, wherein the amount named is often absurdly exaggerated, or may be wholly unintelligible; but regard is to be had to the works and their capacity as actually constructed in interpreting the language of the claim.

Whole volumes have been filled in some of the counties of this State with records of claims to water, but there is no department of record—except the courts in cases of conflict—in which the facts relating to date of ditch or canal construction, location, dimensions, and capacity are or can be preserved. Where the recollection of the oldest inhabitant is often the only source of information, it is extremely difficult to trace the history of irrigation works, and information obtained from owners must be treated with some caution.

This condition of public records in the matter of water appropriation should be remedied at once. The State needs a permanent department whose duty it will be to determine the necessary facts, as well as may be, with reference to every water appropriation and to define the rights

of the several appropriators. There are, of course, many other duties with which such a department might be charged, but it is not proposed to enlarge upon the matter at this time.

After defining the method of appropriating water, as above explained, it was until 1887 further provided in the civil code that "the rights of riparian proprietors are not affected by the provisions of this title." Notwithstanding the repeal of this particular section of the code, all appropriations of water must necessarily remain subject to whatever rights are vested in the bank-land owners.

The first attempt to combine ownership of land and control of water for irrigation in corporations with municipal functions appears in an act to promote irrigation, which was approved by the governor of California on April 1, 1872. This act was a precursor of the irrigation-district law now in force, and provided for the formation of irrigation districts on petition of land owners, and for the construction of works with money secured by assessment of benefits upon the lands in the districts. The affairs of the districts were to be managed by boards of trustees.

This law was restricted in its operation to a part of the State, and remained practically inoperative. Four years later a special law was passed authorizing the formation of the "West Side irrigation district," for which elaborate surveys and studies were made and which was to have been largely dependent upon Tulare Lake as a source of supply. Notwithstanding the recommendation of its engineers and of the commissioners in charge of the matter, the project failed, and district control of water for irrigation purposes was again deferred until the Wright law (named after its author, Mr. C. C. Wright, of Modesto) was passed, in 1887. Much has been hoped from this new law authorizing the formation of irrigation districts. The prime object of the law is to unite ownership of land and water. It is provided that, upon a petition of landowners, lands susceptible of irrigation by the same system of works may be included within the boundaries of a district, which, upon ratification by a vote of the electors therein, is endowed with municipal functions for the specific purpose of securing and distributing water for irrigation.

The affairs of each district are managed by a board of directors, one of whom is elected from each of the five divisions into which the district is ordinarily divided, and until recently amended the law required that each director must be a resident of the particular division of the district by which he was elected. These requirements have recently been modified to the extent that, on the basis of the petition for the formation of the district, only three divisions may be formed, and that the election of the directors may be at large. This was done to overcome difficulties encountered in finding suitable persons to serve as directors in sparsely settled districts. Powers are conferred upon the directors to do everything that may be necessary to carry out the intent of the law and to secure and distribute the

water required for their respective districts. As soon as the probable cost of the works is determined they fix the amount of bonds necessary to be issued, and the question of bond issue is submitted to the qualified electors of the district. Work on district canals is ordinarily done by contract, but may also be done by day labor. It was originally prescribed by law that bonds should not be sold at less than 90 per cent, and as the law now stands no sales are to be made at less than par. The bonds may also be used in paying for completed canals and for water rights and rights of way, but are not to be used for defraying expenses of operation and management.

Difficulties were soon encountered in the application of this law. Almost at the outset it was found that when the exterior boundaries had been fixed by the county supervisors on petition of landowners and the testimony of volunteer witnesses, there was no certainty that correct conclusions had been reached, and the irrigation project assumed to be feasible in advance of an engineering investigation might still be grievously at fault. When taxes were to be collected to meet expenses of examination and surveys, active opposition often became manifest and payments were in many cases greatly delayed. The validity of the law was called into question and was passed upon repeatedly by State courts, and finally by the Supreme Court of the United States, which only recently rendered the decision which conclusively established its validity.

Meanwhile many of the districts which commenced operations under favorable auspices had adopted plans and issued bonds which had been offered for sale with more or less success. The hope that full confidence in the successful operation of the law would be speedily established and that the 6 per cent bonds would soon sell above par was not realized, and despite favorable decisions in the superior courts, confirmatory of the proceedings in individual districts, and favorable action by the supreme court of the State, the bonds did not sell readily. The districts that had been most active in pushing the work on their canals then found themselves in a somewhat peculiar position. The construction funds maintained by the proceeds of bond sales were depleted, the canals and structures were incomplete and of no use until completed, and to current expenses had been added the annual interest and sinking fund account on bonds already sold.

It is hardly surprising that, pending a final decision by the highest tribunal of the country—a decision which was not secured until nine years after the enactment of the law—every resource was exhausted by some of the district managements to continue operations and to derive benefit from completed or nearly completed works. The law requiring bonds to be sold at 90 per cent or more was, in some instances, evaded by selling without requiring the purchaser to guarantee that bonds would be taken as offered. Contracts were then awarded, often without more than nominal competition, and at rates far in excess of

cash value, it being generally understood that the money paid in for any block of bonds quickly returned to the contractors, in exchange for warrants for work performed or material furnished. In other cases ditches were built under supervision of the district engineer by private parties, and after completion were bought by the irrigation district for bonds, which were thus legally disposed of without a direct sale. The cost of works under such conditions necessarily became greater than if all could have been constructed for cash. Sometimes, too, first estimates of cost were too small to complete the system of works even under ordinary conditions, so that supplemental bond issues had to be resorted to, or will yet be necessary, to complete and put the irrigation systems into service.

It is found, too, that the introduction of water into a new district generally brings disappointment. The farmer is not prepared to make immediately full use of the water. Its mere presence in the main canals and laterals is not a guaranty of good crops, and he is often slow to adapt himself to the new methods of farming that become necessary. So the burden put upon the farmer in the shape of increased taxation brings no quick return, and, even under comparatively favorable conditions, dissatisfaction is likely to result.

In the light of ten years' experience the conclusion seems justified that, though endeavoring to establish a correct principle, the law has not been uniformly successful in its operation. State supervision by a competent board of public works, which has the confidence of the people, is a first requirement. This supervision should not be a mere nominal one, but district boundaries and preliminary plans of works should emanate from a department of that character, and no plans should be finally adopted without its approval. Such board should serve the several districts at least in an advisory capacity when required to do so, thereby guaranteeing, as far as may be possible, an adequate source of water supply and an adequate canal system. The bonds of every district should be guaranteed by the State, and all bond sales should be made by the State, so that district construction work may always be done on a cash basis.

Bond issues, after being declared necessary by the directors of any district, are voted upon by the qualified electors of the district. Operations under the law would have been safer and would have commanded greater confidence if the right to vote on all questions involving the expenditure of money or the incurring of an indebtedness could have been restricted to the landowners or the taxpayers of each district. The question of material benefit would in most cases be safer in their hands than if left to a popular vote, which, as the law now stands, is often largely cast by a floating population.

Under the district law the operating expenses are raised either by the levying of an assessment (which must be ratified by a vote) or by charges established by the directors for the use of the water.

There are several irrigation districts in San Joaquin Valley in which canal systems have been brought into actual service, but, as above intimated, the operation of the system does not give general satisfaction. The irrigation districts of the great central valley of California are here briefly enumerated. Those of San Joaquin Valley will again be taken up and treated more fully in connection with the irrigation works dependent upon a common source of supply.

Kraft irrigation district.—This is the most northerly of the several districts in Sacramento Valley, and is situated on the north side of Stony Creek. It was organized in 1888. Its area is 13,500 acres. Stony Creek was to be the source of supply, and bonds to the extent of $80,000 were voted. No bonds were sold, all debts were paid, and no further action under the law is contemplated.

Orland South Side irrigation district.—This district, in Sacramento Valley, was organized in 1888 and is situated on the south side of Stony Creek, directly opposite Kraft district. It has an area of about 26,000 acres and was to be dependent upon Stony Creek for a water supply. No bonds were sold, although $100,000 had been voted. The district organization is dead.

Central irrigation district.—This is the most important district in Sacramento Valley. It extends southerly from near Stony Creek for a distance of about 40 miles, being situated on the west side of the valley, between the base of the Coast Range foothills and the valley trough, and having an average width of about 4 miles. Its area is 156,550 acres. Sacramento River is the contemplated source of supply. The district was organized in 1887. Estimated cost of works, not including rights of way or litigation, was $538,000. Bonds were issued to the extent of $750,000, of which about $200,000 remain unsold. No work has been done since 1891.

Colusa irrigation district.—This is a Sacramento Valley irrigation district, which has remained inactive. It was organized in 1888, on the west side of Sacramento River, intermediate between the river and Central district. Its area is about 100,000 acres, and the bonds voted were $600,000, but no bonds were sold. The proposed source of water supply was Sacramento River, it being intended to use the upper section of a main canal in common with Central irrigation district.

College City irrigation district (proposed).—This was to be a third district, dependent upon the canal which was to divert water from Sacramento River for Central district. Its organization was under contemplation in 1889, but it failed. It was practically a proposed southward extension of Central district.

Browns Valley irrigation district.—This irrigation district, organized in 1888, is situated in the foothills of the Sierra Nevada, on the east side of Sacramento Valley. It has an area of 43,000 acres. Water for its irrigation is diverted from Yuba River. The bonds voted and sold

amount to $110,000. The irrigation system was completed and is in service.

Modesto irrigation district.—This district is situated in San Joaquin Valley, between Stanislaus and Tuolumne rivers. It was organized in 1887 with an area of about 120,000 acres. To cut down cost of works necessary for its irrigation this area was reduced to 81,500 acres by omitting high uplands in the northeastern portion of the original district. After protracted conferences with Turlock district an arrangement was entered into whereby the two districts were to construct a great masonry weir or diverting dam in Tuolumne River in common, the cost of which was to be apportioned to the two districts in equal shares. The district voted bonds to the amount of $800,000 in 1888, which have all been disposed of. A further bond issue of $350,000 has been voted to complete the main canal and to construct distributaries.

Turlock irrigation district.—This irrigation district is situated on the south side of Tuolumne River and embraces the greater portion of the upland or east-side plain of San Joaquin Valley between Tuolumne and Merced rivers, of which the former is to be the source of water supply. It has an area of 176,000 acres. Bonds to the amount of $600,000 were voted soon after the organization of the district, in 1887, and construction work was actively pushed. A second issue of bonds, to the amount of $600,000, was found necessary, and the main canals will probably be completed within a reasonable time.

Madera irrigation district.—This district, organized in 1888, is situated on the east side of San Joaquin Valley to the north of San Joaquin River. Its area is 305,000 acres. San Joaquin River was to supply water for the district. Bonds to the amount of $850,000 were voted, but none were sold. After much litigation it was finally decided to abandon all further proceedings under the district organization.

Selma irrigation district.—The lands watered by Fowler Switch and Centerville and Kingsburg canals have been united in Selma irrigation district. They are situated on the east-side San Joaquin Valley plain, on the north side of Kings River. It was proposed to acquire by purchase the two canals mentioned. The district was organized in 1890. Bonds were to be issued to the amount of $1,000,000, but this bond issue was twice defeated.

Alta irrigation district.—This district is situated on the south side of Kings River, and has an area of 130,000 acres. It was organized in 1888, and bonds to the amount of $675,000 were voted, of which $410,000 were paid for the "Seventy-six" canal system, which has thus become the district canal. Its water comes from Kings River. Permanent head works and a number of distributing canals are yet to be constructed.

Tulare irrigation district.—This district lies in the delta of Kaweah River, encompassing the town of Tulare. It was organized in 1889, and

FLUME ACROSS ST. JOHNS CHANNEL, TULARE IRRIGATION DISTRICT.

has an area of 39,200 acres. Bonds to the amount of $500,000 were voted, of which about $300,000 were paid for existing canals, reservoir site, and water rights, and the remainder went toward the construction of branch canals. Kaweah River is the source of water supply.

Tule River irrigation district.—This district is situated in the delta of Tule River. Bonds were originally voted to the extent of $90,000, and a second issue of $10,000 soon followed. This district was organized in 1891. It has an area of about 22,000 acres and takes water from Tule River.

Tipton irrigation district.—This district is situated to the south of Tule River, from which it was to be supplied with water. The bonds voted amount to $50,000. These bonds and unpaid warrants to the amount of $15,000 were necessary to complete a canal system, which is temporarily out of service by order of the court.

Poso irrigation district.—This is another of the east-side San Joaquin Valley districts. It is situated in Kern County, northward from Kern River, on the north side of Poso Creek, which is its source of water supply. It has an area of 40,000 acres, and bonds were voted to the amount of $500,000. It is one of the districts in which land is almost valueless without irrigation. Its sparse population is indicated by the fact that only 24 votes were cast on the question of district organization, and only 35 on the bond issue. Works are still incomplete, though a portion of the district has water. All bonds have been disposed of.

Kern and Tulare irrigation district.—This district lies in Kern and Tulare counties. It was organized in 1890, and was to have been supplied with water diverted from Kern River. Its area is 84,300 acres. The bonds voted amounted to $700,000. Although about $40,000 were expended in preliminary work, there has been no canal-construction work done by the district.

Huron irrigation district.—This is a west-side district, situated near the base of the Coast Range foothills, to the northwest of Tulare Lake. The district was organized in 1891, and was to be irrigated with water developed largely from the subsurface flow of Los Gatos Creek. It has sold no bonds, and no construction work has been done.

Sunset irrigation district.—This is a very large district, embracing a long, narrow strip of land on the west side of San Joaquin Valley. It extends northward from Tulare Lake about 60 miles, and has an area of 363,400 acres. It was organized in 1889. Bonds were voted to the amount of $2,000,000, and some of these have been issued in return for water rights and rights of way. A contract has been let aggregating $1,500,000 for the construction of its works, and operations under it were to begin soon after a favorable decision on the district law by the Supreme Court of the United States. It is understood that the contractor is now ready to proceed under his contract.

METHODS OF IRRIGATION.

Although water was used for the irrigation of mission gardens in California more than one hundred years ago, irrigation may still be regarded as a new art in this State. Irrigation development was not rapid until within the last twenty years, and methods of irrigation are the result in most cases of attempts to adapt to local conditions the methods in use elsewhere. There was no incentive at the outset to prevent waste, so that the method adopted was very often determined by first cost of land preparation. As the duty of water was gradually raised and the supply allotted per acre of land became smaller, more attention was given to the method of use, and particularly to the reduction of waste. The degree of attention which the suppression of waste receives depends also upon the value of the products of the soil. This has led to the introduction of extensive pipe systems in southern counties of the State for water distribution to irrigators, as well as its delivery on individual tracts at the exact spots where wanted for use. But in San Joaquin Valley, where the volumes of water under control are larger and cultures are generally on a lower scale of value than farther south, the use of pipes is still out of the question. The methods here adopted are more or less perfectly adapted to the peculiarities of climate, soil, and physical features of the tracts irrigated, but vary within wide limits according to the caprice of the individual irrigators.

The methods of irrigation in San Joaquin Valley may be classified as follows:

Irrigation by flooding.
Irrigation from furrows.
Irrigation by saturation of subsoils.
Irrigation from subsurface conduits.

Cereals are generally irrigated by flooding or by saturation of subsoils, sometimes by the furrow method; alfalfa is irrigated by flooding or by saturation of subsoils; fruits and vines are irrigated by any of the methods enumerated; and vegetables, generally from furrows.

Wild flooding.—Water is made to escape over the banks of small ditches constructed on the highest ground, and is controlled in its flow over the surface to be irrigated by attendants. The supply ditch is either at the highest margin of the tract to be irrigated or follows along ridge summits. Water is turned from it into irrigating ditches, which are usually very shallow depressions with flat embankments on their lower sides, over which the water flows in a thin sheet. It is controlled as much as possible by attendants, who try to force it over the entire surface intermediate between irrigating ditches. Surplus water accumulates in the lower ditches and is used again. The preparation of the ground for irrigation by wild flooding is very inexpensive, but the cost of applying the water, owing to constant attendance

required, is relatively great. One attendant is expected to irrigate from 1 to 2 acres a day. The irrigating ditches and their embankments are usually so flat that they do not interfere with farming operations. This method of irrigation is to be regarded as somewhat primitive and is used but little.

Flooding in contour checks.—The land to be irrigated is divided into compartments or checks, each of which is entirely surrounded by embankments of earth. The principal embankments follow contour lines, the vertical distance from one contour levee to the next being uniform. The contour interval usually selected is 6 to 9 inches, rarely so great as 1 foot. It depends in all cases upon the surface slope of the ground to be prepared for irrigation, and should be less than 6

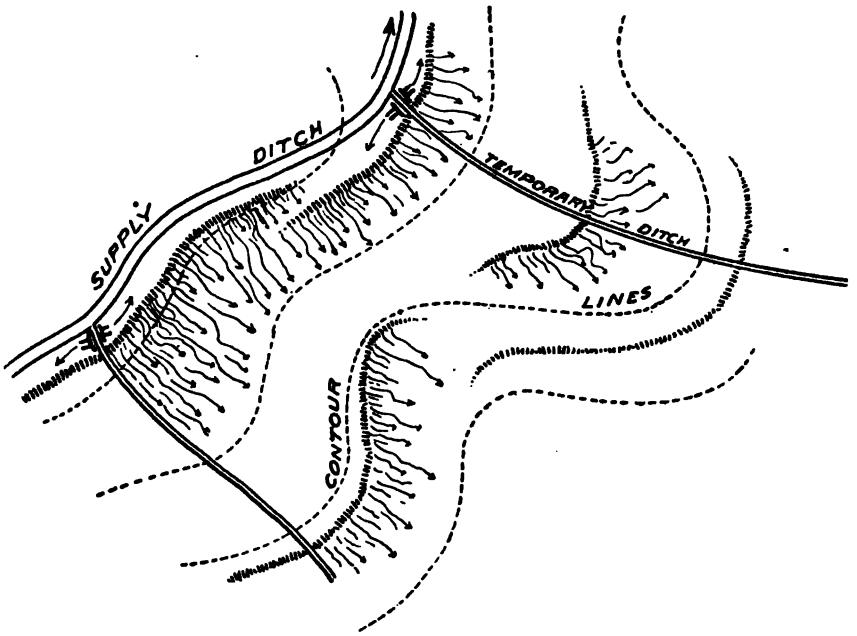


Fig. 2.—Wild flooding.

inches if the ground is sufficiently flat to permit such an arrangement without making the individual checks too small. For ground on a slope that would require levees more than 1 foot apart in elevation some other method of irrigation should be adopted. The strips of land between the contour levees are subdivided by cross levees into compartments of convenient size, which are generally called "checks." Their area should vary according to the volume of water available, a good rule for porous soils being not to exceed one-fourth of an acre for each second-foot when a large head of water is available, and to make half an acre per second-foot the limit for a small supply.

Water is supplied to the several checks in turn from highest to lowest in each series between cross levees. The irrigating ditch which

leads off from the supply canal is usually carried in the direction of greatest slope, cutting the several contour levees nearly at right angles. Irrigation commences by turning a full head of water into the upper check upon one side of the irrigating ditch. This should be filled in from one to six hours. In the full check water should be barely over the highest portion of the ground, but 6 inches to 1 foot deep in the lowest portion of the check, according to contour interval. The contour levee should have its top about half a foot above the water surface of a full check. When the upper check is entirely submerged, gates are opened from the irrigating ditch into the next lower check, those admitting water to the upper check are closed, and one or more

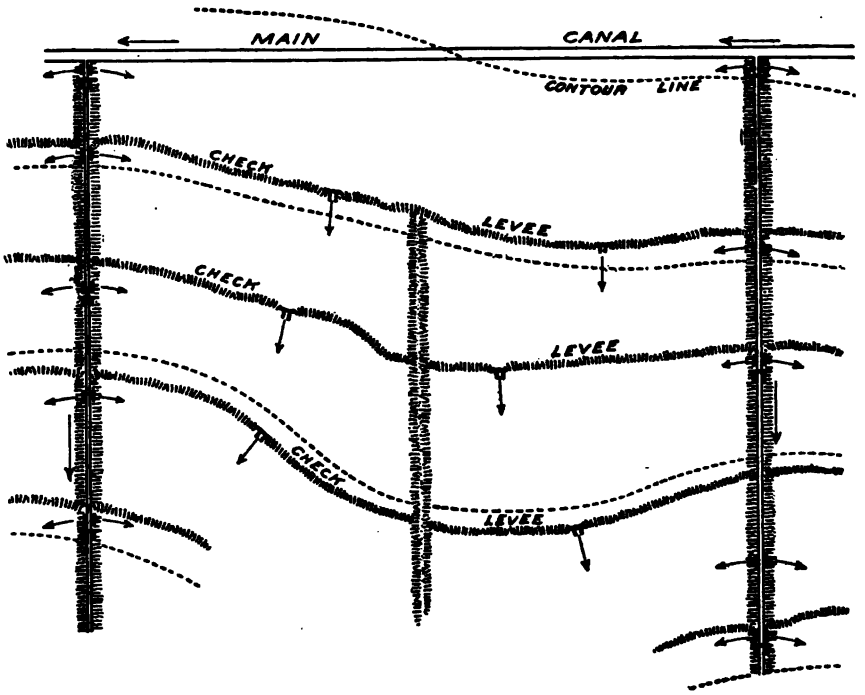


FIG. 3.—Flooding in contour checks.

gates in the contour levee between the two checks are opened to permit the surplus water from the first to drain into and assist in submerging the second one. This will require less time to fill than the first, because the supply of water from the ditch is augmented by the run-off from the upper check.

The irrigating ditches frequently replace cross levees, so that water can be admitted to a check from both sides at once.

When the average time required to fill checks on sandy soils exceeds three hours, it may generally be assumed that water is wasted; either the checks are too large or there is not enough water turned in. Heavy soils, however, do not take up water rapidly, and, aside from requir-

IRRIGATION BY CHECKS IN SAN JOAQUIN VALLEY.

ing more time to absorb water, they do not permit its flow to subsoils so readily as do sandy soils, consequently more time may be allowed to fill a check in clayey soil without undue waste. Twenty-four hours should be regarded as the permissible limit.

Checks are occasionally very large. One was found in service under the Calloway Canal having an area of 60 acres. The water supplied to it was reported to have been as great as 250 second-feet. Such areas in one check are never advisable and are merely temporary features of a growing system. Eight to 10 acre checks are large, and those of 2 to 5 acres are generally preferred.

Embankments around the checks may be either permanent or temporary. The latter are rare. Permanent check levees are made of two types, either with very steep sides and narrow tops, so as to occupy as little space as possible, or very broad and flat, so as not to interfere with farming operations. The flat embankment becomes a part of the cultivated area and generally is the most productive part of the irrigated field. It is constructed by scraping up material from a broad area on both sides if the ground is nearly level, or from the lower side only if the ground is comparatively steep. The cost of preparing land for this method of irrigation in permanent checks ranges from $2.50 to $5 per acre, the cost of the necessary distributing canals, ditches, and structures from $3 to $5 per acre. These figures, of course, may be greatly exceeded if the ground has too great a slope or is very much broken by hogwallows, or swales and ridges. Irrigation by this method is much less expensive than by wild flooding. The only work required of attendants is the opening and closing of gates and the guarding of the check levees. When ground is well prepared for this method of irrigation and the supply of water is abundant, the cost of each application of water will range from 3 to 30 cents per acre. The best examples of irrigation by this method are found on Kern Island; under Calloway Canal; on Buena Vista farm, watered by the Kern Valley Water Company's canals; near Borden and Madera; on the Riverside, Columbia, and Chowchilla ranches, irrigated by the Chowchilla Canal; on the west side of the San Joaquin, under the San Joaquin and Kings River Canal; and at various other points.

Flooding in rectangular checks, not level.—The subdivision into compartments of the land to be irrigated is carried out on straight lines, and levees are built on these lines. The subdivision may be planned with some regard to the direction of the contour lines and lines of greatest slope, or these may be entirely ignored. The advantage of this system over subdivision or contour lines is better conformity with property limits and culture borders, but it has many disadvantages when the surface of the ground is not very smooth. Levees are not uniform in dimension, as is the case with the principal levees under the contour system. It is difficult to avoid leaving low spots, which interfere with thorough drainage, and the first cost of land preparation is

generally somewhat greater than when contour levees are used. The method of applying water is substantially the same as in the case of contour-check irrigation. Flooding progresses in the direction from highest to lowest ground.

A good example of this method of irrigation is to be seen on the Kohler, West & Minturn tract, near Minturn. The soil is a light, sandy loam, underlain by a hardpan, which is near the surface at the eastern limit of the tract, but which dips westward. The soil water is about 14 feet below the surface. When irrigation is in progress with a full head of water (about 16 second-feet is so considered by its owners), six men are required to manipulate gates and guard check levees. These attendants work in two shifts of three, each for twelve

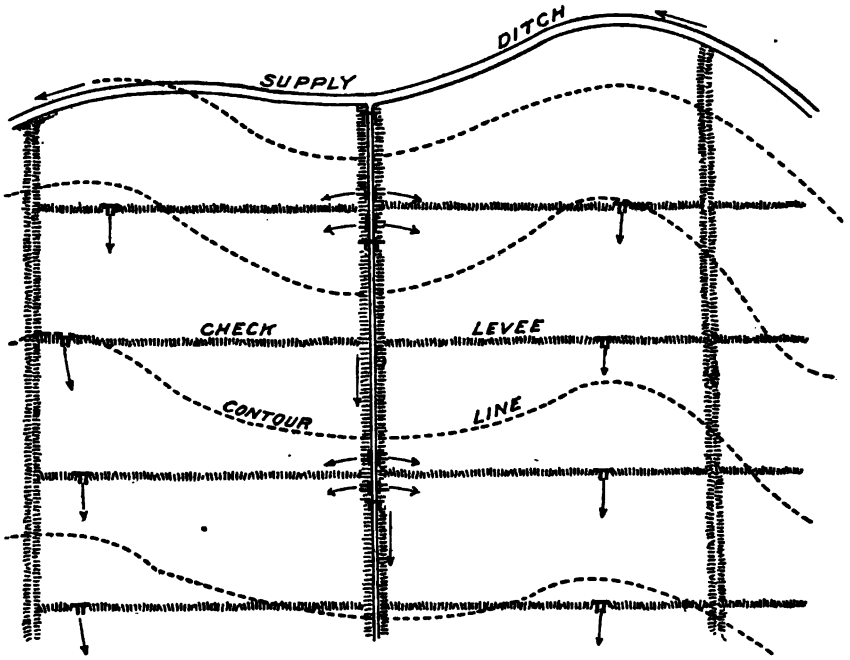


FIG. 4.—Flooding in rectangular checks, not level.

hours. The progress made is at the rate of about 20 acres a day. On the same tract some land is subdivided on the contour plan. Where this is the case the rate of progress is nearly twice as great, but this difference in the duty of water is not to be ascribed solely to the method of irrigation; the rectangular checks are in the western portion of the tract, where soil is lightest and deepest, and where duty of water is naturally least.

Flooding in level checks.—The surface of the ground in each compartment is made perfectly level and smooth. In such cases the check levees are low. Checks are made small to reduce cost of land preparation. The amount of material to be moved when the original surface is

smooth increases with the square of the dimension of the checks in the direction of greatest slope. All checks are usually made rectangular. Land preparation for this method of irrigation is always expensive, but where the surface needs special treatment, as in the case of the knolly or "hogwallow" lands, the excess of cost over other methods is inconsiderable. The first irrigators near Fresno adopted this method, and it has long remained in favor in that locality. The first application of water was often accompanied by peculiar phenomena, notably in the nature of an irregular surface settlement, due in part to a copious flow from the surface into subsoils, which often caused a general breaking down of the surface. In refilling the depressions caused by the first wetting a level plane was established for each check, regardless of the nature of the crop to be irrigated, and this system of leveling the ground in each check has become a characteristic feature of irrigation near Fresno.

The area of the checks is made small, generally less than 1 acre, usually one-quarter to one-half acre. Water is admitted to the several checks from small irrigating ditches, and is shut off as soon as it has spread over the whole surface of each. There is ordinarily no drainage from level checks. All water admitted to each is allowed to sink into the soil. Not more than three hours should be required to fill a check with water, soil being ordinary sandy loam. If more time is required the supply of water should be increased or the size of the check should be reduced.

In 1882 an irrigator near Fresno was observed irrigating four small checks of alfalfa. His water supply was small, only 2.26 second-feet. Instead of turning all the water in turn into the several checks, he apportioned it to the four, and the time to fill them was ten hours, whereas not more than an hour apiece would have been required had they been filled one after the other.

The cost of preparing land for this method of irrigation, including the necessary small ditches and gates, ranges from about $15 to $50 per acre. The cost of applying water is inexpensive. The attendant in charge usually has time for other work, it being ordinarily only necessary to turn the water off and on.

Flooding between parallel levees.—This is a recent modification of the primitive system of wild flooding, especially adapted to such cultures as alfalfa and growing cereals. Low parallel embankments, generally 50 to 100 feet apart, are constructed in the direction of the land's greatest slope. Water is delivered, at the upper end of a strip of land between two of these embankments, into a ditch whose downstream bank is usually raised slightly above the general surface of the ground, and is made level. Enough water is admitted to this ditch to cause an overflow of 1 to 2 inches over this bank, and this overflow is maintained until water reaches the lower end of the strip of land. Ordinarily the water will spread from levee to levee. If it shows too great tendency

to concentrate on fixed lines, and fails to spread, it is intercepted with other ditches or depressions similar to the one at the head of the strip of land, and the flow from levee to levee again becomes uniform.

All embankments are ordinarily very low and flat, so that farming operations will not be interfered with. The cost of land preparation for this method is about $5 to $10 per acre.

Furrow irrigation.—The method of irrigation by running water in furrows or small temporary ditches made with the plow is a common one in San Joaquin Valley. It is the method generally adopted for the irrigation of fruits, vines, vegetables, hops, or other cultures usually arranged in parallel rows. Water is allowed to flow in furrows, from which it sinks into the soil, being most readily absorbed by the upper layers which have been loosened by plowing. Occasionally drainage is combined with furrow irrigation; more frequently, however, no attention is paid to drainage, the aim being to supply to each furrow only the amount of water that will be absorbed by the soil. The flooding of portions of the ground's surface, as by the furrow methods, compacts the soil, thereby facilitating the return of moisture from below the surface, where it evaporates. To destroy the capillary action of the surface layer, it is necessary to use the hoe or some other implement before it becomes too dry and baked.

Furrow irrigation of cereals.—Cereals are not ordinarily irrigated by the furrow method, but this method of rapidly supplying moisture to a grain field not specially prepared for irrigation has often been resorted to when conditions seemed to justify a special effort to save a parching crop. Sometimes, too, land is wet in the fall of the year, before sowing, by this method.

If the slope of the ground's surface be not too great the furrows, which are generally deep, single plow furrows, are run in the direction of the slope. They are placed 8 to 12 feet apart, according to the porosity of the soil. Water is admitted into them from small ditches, generally crossing them at intervals of 100 to 200 yards. The irrigation commences at the highest part of the field. Water is admitted into a number of furrows at the same time, and the flow is checked or aided in each by an attendant, so as to keep progress uniform and to accomplish a general soaking of the ground's surface. This system of irrigation involves much labor and careful watching. It is relatively expensive. Should the surface of the ground have too great slope, the plow furrows are drawn across the direction of greatest slope on predetermined grade lines. As soon as irrigation is complete the furrows are plowed in, so that they may not interfere with farming operations.

Furrow irrigation of permanent cultures.—The usual method of irrigating trees, vines, or plants set out in rows is to allow water to flow between the rows in plow furrows or small ditches. When rows are far apart, two or more furrows are drawn between rows; ordinarily, however, one deep furrow between each two rows is preferred. The

A. FURROW IRRIGATION OF VINES.

B. FURROW IRRIGATION OF ORCHARD.

direction of furrows is not always restricted to that of rows of trees, etc., but may be determined by other considerations, such as slope of the ground's surface. Small ditches surrounding individual trees or plants are sometimes connected with the irrigation furrows. It is better to prevent the water from standing around trunks of trees, but no rigid rule can be laid down; the spacing of irrigation furrows is governed by the character of the soil to be irrigated, and is determined for each locality by experience.

Water is usually turned into a number of the irrigation furrows at the same time. At the lower end it may be received into a drain ditch which carries it off for further use. The time required for irrigation from each furrow is somewhat indefinite, but the endeavor is always made not to let water flow longer than may be necessary to give a reasonable supply to the soil. The several furrows are generally less than 300 feet long. Irrigation progresses from highest to lowest portion of the tract to be irrigated. This method of irrigation is in general use without regard to character of soil, but gives particularly good results on comparatively heavy soils which do not absorb water rapidly. When soils are porous and take water from the furrows freely, the furrows are kept shorter than in heavier soils.

Furrow irrigation in level checks.—When, a few years ago, it was feared that the ravages of the phylloxera might extend into the vineyards of Fresno County, it was deemed advisable by some vineyardists to set out all vines in checks which could be completely submerged. Fortunately such submersion, to combat the phylloxera, has never become necessary. But the preparation of the ground for flooding in checks led to a new method of applying water to the land. From a supply ditch, water is admitted into a small ditch upon one side of each check, and from this small ditch it enters deep horizontal furrows which have been drawn between each two rows of vines. As soon as water has filled all the furrows irrigation is complete, and the accumulated water is allowed to sink into the ground. No drainage is combined with this method of applying water.

Furrow irrigation of vegetables.—Where irrigations are to be frequently repeated, as in the case of such products as vegetables, berries, etc., each row of plants is generally set on a ridge a few inches to a foot in height. The length of the rows is varied according to slope of the ground in their direction. The depression between each two rows is utilized as a furrow, which generally receives very little or no fall from end to end. Water is supplied to one end of a set of such parallel depressions, and rises in these to near the height of intervening ridges. It is generally allowed to soak into the ground without drainage.

Irrigation by filling subsoils with water.—The success of farming with irrigation in the Mussel Slough country has attracted particular attention to this method of irrigation. As soon as water was introduced in the canal systems of these very flat lands of the Kings River delta, it

was found that spots quite remote from the canals and ditches became moist, and that it was not necessary, as in other portions of the valley, to apply water to the surface of the ground. This wetting of the lands was attributed to lateral percolation. Soils were supposed to possess some peculiar property which facilitated the transmission of moisture horizontally, and it took a number of years to make clear to the irri-

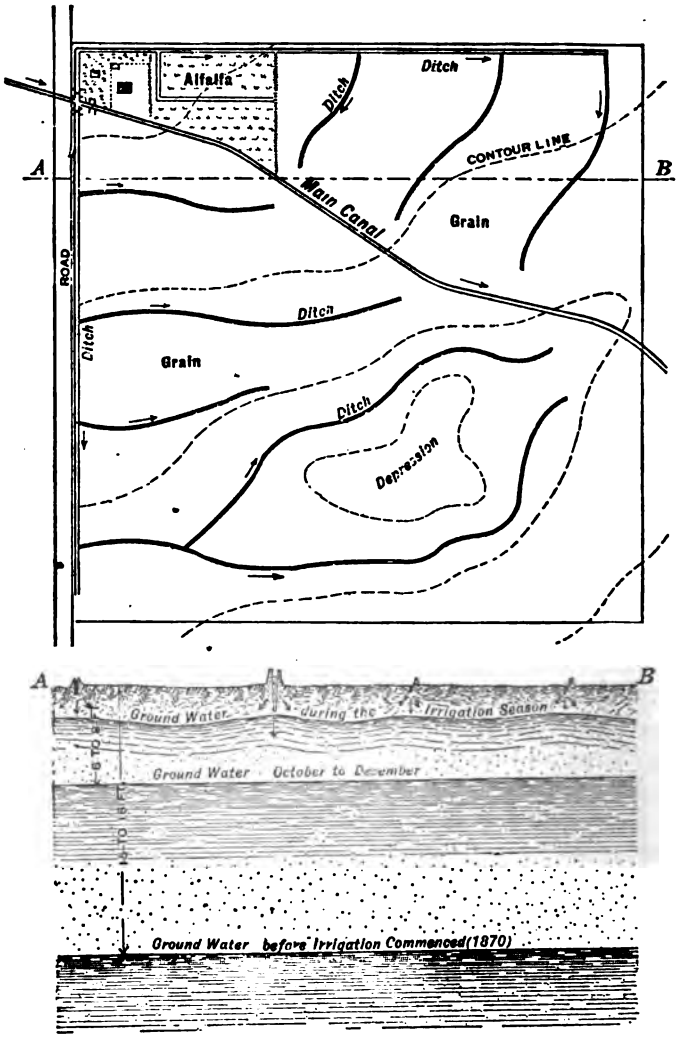


FIG. 5.—Irrigation by filling subsoils with water, Mussel Slough country; map and section.

gators what actually did take place. The soil water of that region before the construction of irrigation canals was at 10 to 18 feet below the surface; now it does not fall below 8 feet. It is kept under control by regulation of the supply in the irrigation ditches and by a natural subsurface drainage, which, as indicated by the slope of the ground-water plane, may be into Tulare Lake.

FURROW IRRIGATION OF GROVE.

This system of irrigation involves but little more than the introduction of water into irrigating ditches in the spring, when the supply is most abundant in river and canals. Irrigating ditches for this purpose are generally constructed about an eighth of a mile apart. They are either permanent or only temporary features of the irrigation system. They receive a very light grade, in order that they may be maintained full, with water flowing sluggishly.

The water sinking from main canals and distributaries and from the irrigating ditches causes a general rise of the ground waters to within 2 or 3 feet of the surface. This occurs late in April or early in May, and as soon as moisture can be detected in the low spots of any field its irrigation for the season is complete.

Careful inquiry in the Kings River delta established the fact that before 1870—that is, before the construction of irrigation works in that section of the valley—the depth to ground water was very generally 15 to 18 feet. It approached to within 10 feet only at a few points nearest the valley trough. It is now kept fluctuating between the limits already indicated, approaching to within 2 to 4 feet of the surface in spring and then settling down to about 8 feet late in the fall.

Irrigation by this method can not be restricted to particular tracts of land; its benefits may extend far beyond any individual tract to be irrigated, and it has frequently happened that lands lying between irrigated farms have derived the full benefit of irrigation without contributing to its cost.

The preparation of land for this method of irrigation is inexpensive, the only necessary cost being the construction of the small ditches. Very little attendance during irrigation is required. Alfalfa lands are sometimes prepared for flooding in order that gophers may be killed, when necessary, by a complete submersion of the cultivated tracts.

The advantages already indicated for this method of irrigation are offset by a decided disadvantage. The rising water brings to the surface alkaline salts, which gradually accumulate and may render unfit for cultivation soils that were originally entirely free from an excess of objectionable salts. Something has been said on this subject in treating of irrigation works in the Mussel Slough country (see page 17).

It remains to be added that the rise of the water table near Fresno has been so pronounced, as a result of the extension of the irrigation systems, that many of the tracts which were originally prepared for irrigation by some other method are now so wet that they are in need of drainage. On many others the application of water to the surface has ceased.

Subirrigation, or irrigation from subsurface conduits.—This method of applying water to land has not been so satisfactory as was hoped, but, having been introduced in some localities on a large scale, it should not be passed without notice.

The intent of this method of irrigation is to supply a moderate quantity of water directly to those parts of the soil where moisture is needed without wetting the surface of the ground. Thereby it was hoped to economize water, to greatly simplify its control and distribution, to cheapen irrigation, and to avoid baking of soil and the necessity of breaking up its surface after each application of water.

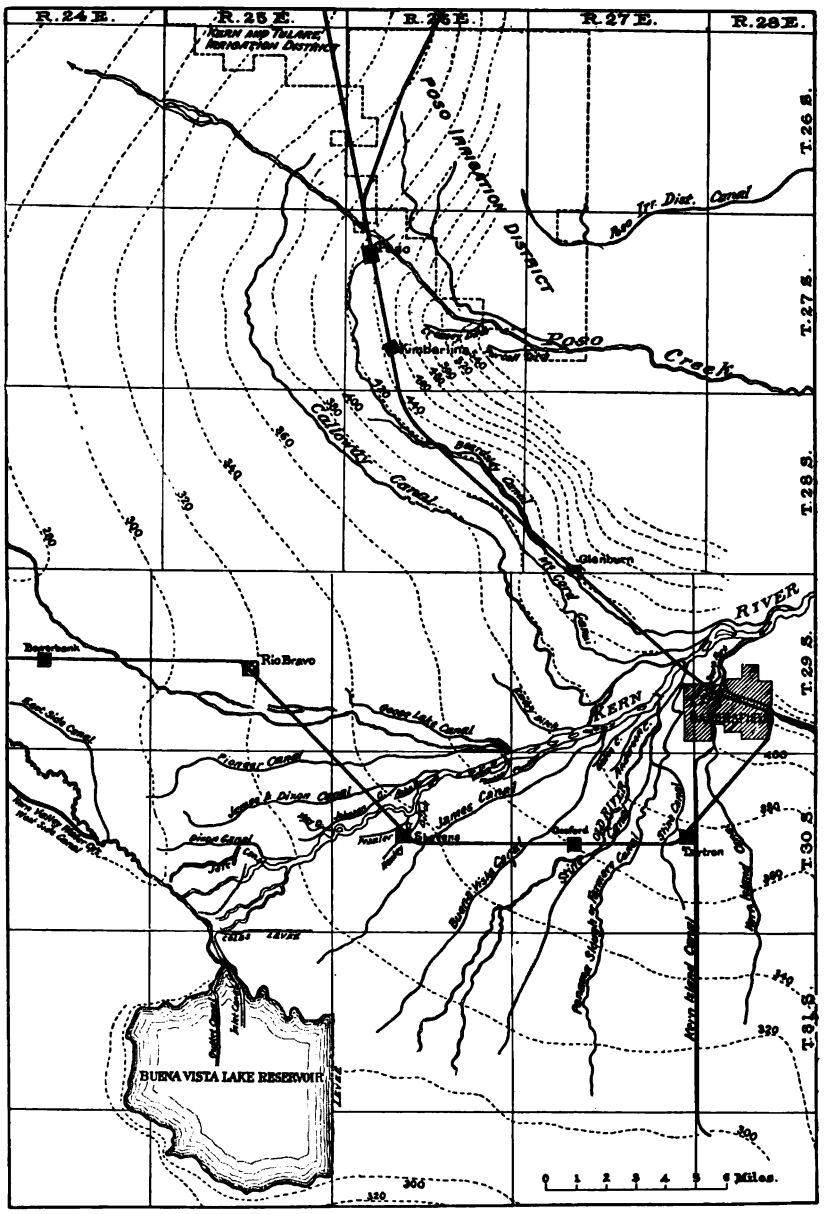
Water is distributed to all parts of the land to be irrigated in cement pipes, from which it escapes through perforated plugs of wood. It is admitted into these pipes under a low pressure, sufficient to insure the escape of some water even in the highest parts of the land to be irrigated. The system is applicable only to smooth-surfaced tracts having but slight slope.

The final distributing pipes are constructed by a peculiar machine. They are made in place and are continuous. The diameter of their bore is 2 inches. At intervals, corresponding to the distance between trees or vines, they are perforated from above, and a wooden plug with a hole about one-sixteenth inch in diameter, lengthwise through it, is inserted in the perforation. This plug is protected by means of a hollow cap, or earth guard, resting loosely upon the pipe over it. The pipe is placed 20 inches or more below the surface of the ground, so as not to interfere with plowing, cultivation, etc. Water is conducted to the 2-inch pipes—which may be laid between each two rows if the rows be far apart, as in the case of trees, or between alternate rows if they be close together, as in the case of vines—by means of a system of 6-inch and 4-inch pipes, which in turn receive water from a main supply pipe, generally about 8 inches in diameter. At all points where the 8-inch and 6-inch pipes branch, vertical cylinders, opened at the top—so-called hydrants—are introduced, by means of which the water may be shut off from one line or the other of pipe. This is accomplished by holding the inlet pipe higher in the cylinder than the outgoing pipe, and providing a seat for a disk to be inserted between the two.

When water is being supplied to any part of a vineyard or orchard, it will escape through the plugs into the ground, and its quantity must be sufficient to keep the stand in the hydrants everywhere above the highest parts of the 2-inch pipe system, so that there may be no doubt that water is escaping from every plug in the tract under irrigation.

Under favorable conditions it will cost about $50 per acre to prepare ground for irrigation by this method. The roots of trees and plants will, notwithstanding every precaution to prevent it, find their way into the lines of pipes at exposed points, and may in time seriously interfere with their successful use.

Until irrigators are required to be very much more economical in the use of water for irrigation than at present, the matter of expense alone will interfere with any extended use of this system of irrigation.



KERN RIVER DELTA.

KERN RIVER.

HYDROGRAPHY.

Kern River is the most southerly of the large streams descending from the slopes of the Sierra Nevada into San Joaquin Valley. It breaks through an outlying spur of the main range in a deep, rocky gorge, which terminates abruptly about 10 miles east of Bakersfield. For a distance of 18 miles from the canyon mouth the river flows westerly between high, gravelly bluffs, in which the adjacent rolling lands and mesas terminate. Occasional low, level tracts border it. From between the flanking hills and uplands the river emerges upon the plains of San Joaquin Valley just northeast of Bakersfield. Thence the main stream has a southwesterly course, flowing in a shallow bed 300 to 800 feet wide nearly 20 miles, to a point within a few miles of the trough of the valley; thence southerly into Buena Vista Lake, now used as a reservoir for irrigation purposes.

Year after year the sandy material eroded by the river from its mountain watershed has been deposited in San Joaquin Valley below the point at which the river emerges upon the plain. New channels have been constantly forming while old ones were being obliterated, and the delta region thus built up extends 20 to 25 miles toward the south and west, terminating in a great semicircle formed by Kern and Buena Vista lakes and the upper portion of Buena Vista Swamp. The central portion of this delta is generally referred to as Kern Island. The flow of water in many of the delta channels is now under control, and they are classed as canals.

Principal among these delta channels are: South Fork, or Old South Fork, which has a southerly course from its head, about 2 miles northeast of Bakersfield, to its outfall into Kern Lake; Old River, which has a southwesterly course from its head, about a mile and a half west of Bakersfield, toward a point between Kern and Buena Vista lakes; and Buena Vista Canal Slough, also flowing southwesterly, which leaves the new channel of Kern River about 2 miles below the head of Old River. Of these channels South Fork was the main channel of the river until 1862. Old River then became the main water way, and remained so until New River was formed by the freshets of 1867–68.

Kern River enters San Joaquin Valley with a total mountain drainage area of 2,345 square miles. By far the greatest portion of the region drained lies in the high Sierra Nevada. Precipitation in the highest portions of the river's drainage basin is generally in the form of snow. But an occasional heavy rain falling on large deposits of snow causes great freshets, generally early in the spring. Ordinarily the river is at a low stage from September to January, inclusive. It is at a high stage from April to July, and at a medium stage in February and March, and in August.

The discharge of the river has been estimated by the State engineering department for the six years 1878 to 1884. According to the results of this estimate, which is based on many measurements and an imperfect record of rise and fall of the river, the average amount of water supplied by Kern River was about 430 second-feet for the months November to January (inclusive); 800 second feet for February to April; 2,450 second-feet for May to July; and 570 second-feet for August to October. The average annual flow of the river for that period was rated at 1,110 second-feet.[1] The discharge of the river as here noted refers to the State engineering department gaging station,

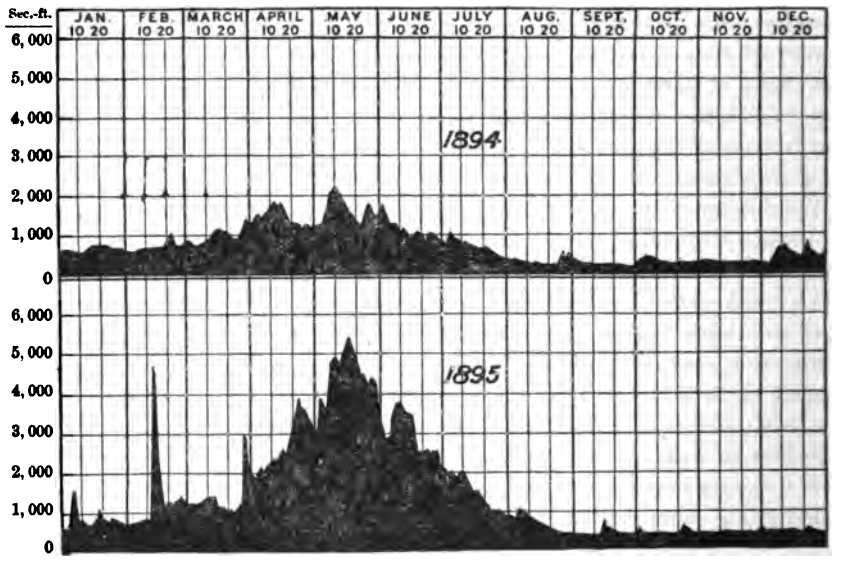


FIG. 6.—Discharge of Kern River, California, 1894–95.

about 3 miles below the point where the river breaks from its mountain gorge and enters upon its course across porous alluvial deposits.

Measurements made by Mr. A. K. Warren, under the direction of Mr. Walter James, chief engineer of the Kern County Land Company, show the facts indicated in the following table and accompanying diagram in regard to the discharge of Kern River for the four years from 1894 to 1897.[2]

[1] See Physical Data and Statistics of California, collected and compiled by the State Engineering Department of California, Sacramento, 1886, pp. 410, 470–472, 476–477.

[2] Bull. U. S Geol. Survey No. 140, 1896, pp. 267–274. For further information concerning the flow of Kern River see Twelfth Ann. Rept. U. S. Geol. Survey. Part II, 1891, p. 319, Pl. LXXX; Bull. U. S. Geol. Survey No. 131, 1895, p. 79; Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, 1897, p. 395.

Estimated monthly discharge of Kern River at Bakersfield, California.

[Drainage area, 2,345 square miles.]

Month.	Discharge.			Total.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1893.	*Second-feet.*	*Second-feet.*	*Sec.-feet.*	*Acre-feet.*	*Inches.*	*Sec.-feet.*
October	554	517	534	32,861	0.26	0.23
November	559	467	518	30,827	.24	.22
December	590	430	516	31,757	.25	.22
1894.						
January	741	762	661	40,644	.32	.28
February	1,114	604	717	39,817	.32	.30
March	1,443	762	1,001	61,541	.65	.43
April	1,892	1,209	1,495	88,952	.71	.64
May	2,208	1,228	1,607	98,798	.79	.69
June	1,719	871	1,085	64,557	.51	.46
July	1,051	400	700	43,036	.34	.30
August	549	256	335	20,565	.16	.14
September	382	172	248	14,756	.12	.11
October	363	224	279	17,178	.14	.12
November	268	230	244	14,500	.11	.10
December	805	234	470	28,908	.23	.20
Per annum	2,208	172	737	533,252	4.40	.31
1895.						
January	1,616	473	809	49,762	.40	.34
February	4,762	675	1,252	69,536	.55	.53
March	3,004	987	1,374	84,437	.67	.59
April	3,897	1,911	2,724	162,076	1.29	1.16
May	5,384	3,100	4,369	268,608	2.14	1.86
June	3,721	2,174	2,906	172,919	1.37	1.24
July	2,063	867	1,482	91,113	.73	.63
August	1,073	354	629	38,665	.31	.27
September	676	290	344	20,469	.17	.15
October	612	276	327	20,106	.16	.14
November	436	308	346	20,588	.17	9.15
December	447	368	403	24,779	.20	.17
Per annum	5,384	276	1,413	1,023,058	8.16	.60
1896.						
January	3,101	377	747	45,931	.37	.32
February	798	559	617	35,489	.28	.26
March	2,089	652	951	58,475	.47	.41
April	1,262	766	972	57,838	.46	.41
May	3,370	934	1,401	86,144	.69	.60
June	3,611	1,244	2,476	146,142	1.17	1.05
July	2,210	741	1,346	82,762	.66	.57
August	741	353	486	29,883	.24	.21
September	473	234	304	18,089	.14	.13
October	425	223	267	16,417	.13	.11
November	416	288	355	21,124	.17	.15
December	426	313	347	21,336	.17	.15
Per annum	3,611	223	854	619,630	4.95	.36
1897.						
January	832	350	373	22,935	.18	.16
February	2,306	516	809	44,930	.36	.35
March	2,044	688	923	56,753	.45	.39
April	4,410	1,094	2,914	173,395	1.38	1.24
May	5,342	4,054	4,580	281,613	2.25	1.95
June	4,352	1,289	2,308	137,395	1.09	.98
July	1,536	644	1,006	61,857	.49	.43
August	671	338	469	28,838	.23	.20
September	363	260	295	17,554	.14	.13
October	441	278	340	20,906	.17	.15
November	447	289	355	21,124	.17	.15
December	1,023	327	422	25,948	.21	.18
Per annum	5,342	260	1,234	893,248	7.12	.53

1894. Maximum discharge, May, 2,208 second-feet; minimum discharge, September, 172 second-feet; average for the year, 737 second-feet.

1895. Maximum, May, 5,384 second-feet; minimum, October, 276 second-feet; average for the year, 1,413 second-feet.

1896. Maximum, June, 3,611 second-feet; minimum, October, 223 second-feet; average for the year, 854 second-feet.

1897. Maximum, May, 5,342 second-feet; minimum, September, 260 second-feet; average for the year, 1,234 second-feet.

The gaging station of the State engineering department was located on the Rio Bravo Ranch, about 3 miles below the termination of the river's granite canyon, a short distance below the point where in 1879 the material of which the river bed was composed changed in character from bowlders and cobbles to gravel and sand. The several measurements made subsequent to that time, and until the close of the work of the State engineering department, showed a gradual erosion of the river bed, resulting in a downstream movement of the upper end of the gravel and sand bars, which led to inquiry concerning conditions in preceding years and to the conlusions that a few years subsequent to the great freshet of 1861–62 the sand and gravel bars were at a much higher level than in 1879; that erosion had continued from year to year, though at a somewhat irregular rate, until 1884 and was then still in progress; that the aggregate erosion during the five years covered by observations was 5.3 feet, and that at some time preceding the freshet of 1861–62 the river had for a long period occupied a bed fully as low as that of 1883. A row of trees planted at the water's edge at a mean stage of the river about 1868, and now well above the reach of the water, has been pointed to as evidence of a former higher position of the river bed. On the other hand, deep, well-worn depressions made by the Indians in grinding food materials in the tops of great granite bowlders, barely projecting above the low-water stage of the river in 1883, gave evidence of a preceding protracted low position of the river bed. It seems reasonable to expect, therefore, that other great freshets may again temporarily fill the river bed with sand and gravel, and that in years of ordinary flow, such as the entire series of seasons since 1867–68, the river will have a tendency to continue its erosive action.

Due allowance for the changes in actual elevation of the river bottom were, of course, made in interpreting results at the gaging station.

The original course of Kern River waters, westerly and southerly across its delta, widely dispersed in numerous channels, has by natural agencies, aided by the operations of man, been modified to the extent that now at high stages all water in excess of the capacity of the irrigating ditches and canals is kept under reasonable control in one main channel having a direct southwesterly course toward Buena Vista Lake.

Buena Vista Lake has been shut off at the east from its connection with Kern Lake by means of a high levee, which has a north-south course, following the line between Rs. 25 and 26 E. for a distance of over 5 miles.

A. KERN RIVER, LOOKING DOWNSTREAM FROM CANYON.

B. KERN RIVER, TWO MILES BELOW CANYON, LOOKING UPSTREAM.

Thus Kern River water is prevented from reaching Kern Lake, the bed of which is now dry, arable land, and Buena Vista Lake is converted into a large reservoir, the capacity of which is said to be about 150,000 acre-feet. From the northwestern margin of Buena Vista Lake an outlet canal leads into Buena Vista Slough and thence to canals proper of the Kern Valley Water Company, of which the westernmost one, located near the western margin of Buena Vista Swamp, has been planned large enough to afford passage for the outflow waters from the lake when the reservoir is full and the river is high. This canal, therefore, for a long distance takes the place of Buena Vista Swamp, which was the original water way, conducting the outflow from Buena Vista Lake into Tulare Lake. The three lakes which have been or are the recipients of water from Kern River are very flat depressions, without well-defined banks. The beds of Kern and Buena Vista lakes are at an elevation of about 285 feet above sea level; the bed of Tulare Lake is at an elevation of about 175 feet. The area covered by Kern and Buena Vista lakes combined (before the spread of water was restricted artificially) was about 80 square miles when the lakes were full, at which stage the maximum depth of water in either did not probably exceed 14 feet. The area of Tulare Lake fluctuates between 195 and 760 square miles, but the lake water has not spread to the extreme limit of the full lake since 1868.

The lands of the east side of the San Joaquin Valley plain, commanded by the Kern River canals, are very smooth surfaced. Those of the river delta slope uniformly toward the west and south at the rate of 6 to 7 feet to the mile. The only surface inequalities on Kern Island are due to the land-building tendency of the river, which has left broad, low ridges of sand to mark the alignment of channels of former epochs in its history. On the north side of Kern River the delta lands merge almost imperceptibly into the granitic sandy lands of the general valley plain, and the gentle westerly slope from the base of the foothills of the Sierra Nevada is almost unbroken to Buena Vista Swamp.

SOILS AND RAINFALL.

Near the base of the foothill belt, northward as well as southward from the river, the soil is a coarse granitic sandy loam, showing an occasional growth of cactus, and rather forbidding in appearance, yet very productive with water. To the southeast of Kern Lake a large area of fine sandy loam, known as the Weed Patch, marks the sink of Caliente Creek. The soils of the eastern portion of Kern River delta are generally loams, ranging from those rich in clay to soils of a peaty character and to soils of almost pure sand. Different kinds of soil are here frequently found close together, and it is often remarked that probably no single square mile of land could be found whose soil would

not have to be put into several classes. Toward the south and west on Kern Island the soil becomes heavier, and near the high-water line of the lakes it is strongly impregnated with alkali. It has a peaty character in the swamp-land areas adjacent to the lakes, also northwestward from Buena Vista Lake throughout the broad tract known as Buena Vista Swamp, which extends about 40 miles northwesterly toward Tulare Lake. These swamp lands were originally covered with a dense growth of reeds—"tules." Their soil is generally a light black vegetable loam or mold, underlain by a dark-colored clay. Eastward from these swamp lands, which mark the trough of San Joaquin Valley, is a long parallel strip of alkali land of inferior quality, which lies to the west of a narrow strip of fertile land flanking the Goose Lake Slough channel. Farther eastward are the sandy loams and coarse granitic soils of the main east-side plain. These generally have a substratum of dry, fine yellow clay, sometimes of sufficient hardness to be called hardpan. This is usually found at a depth of 3 or 4 feet.

The southern or upper end of San Joaquin Valley, in which lie the lands commanded by the Kern River waters, is a region of very light rainfall. The annual average fall is about 5 inches. Profitable cultivation of the soil without the aid of other water to supplement the scant rainfall is not possible.

Kern River water is used to a small extent for irrigation in the valley of South Fork far up in the mountains, also for the irrigation of relatively small areas of bank and mesa lands within the foothill section of the river's course; but the region of principal use is the river delta and a broad expanse of country extending far northward from the river and lying below the base line of the foothills.

CANALS AND DITCHES.

Rio Bravo Ranch canals.—Kern River crosses the foothill belt in a valley, generally one-half mile to a mile in width, with occasional strips of bottom land on one bank or the other. These are frequently backed by higher terraces or mesas with rich, black loamy soil, beyond which the hills rise in irregular disconnected ranges. The Rio Bravo Ranch lies just below the point where the river breaks out of its canyon. Several small ditches have here been built for local irrigation. A water-wheel was first made use of. It was constructed in 1879 by Mr. John Barker, and was intended to lift water 28 feet. The wheel is reported to have delivered the quantity of water expected, but the land required more than was anticipated; consequently the wheel was soon abandoned as a source of supply, and a direct diversion into a ditch constructed along the base of a high bluff on the south side of the river was resorted to. The river, however, for a series of years was there deepening its channel, rendering necessary frequent extensions of the head of the ditch upstream, and making ditch maintenance expensive. Its cost has probably been somewhat in excess of $3,000.

A. HEAD OF KERN ISLAND CANAL, LOOKING UPSTREAM.

B. HEAD OF KERN ISLAND CANAL, LOOKING DOWNSTREAM.

the successor in interest of the reclamation district that had already been formed. The canal company was therefore formed with the avowed purpose of protecting from overflow and of supplying with water for agricultural, domestic, and manufacturing purposes a territory of about 120,000 acres. The Kern Island Canal Company acquired the ditch and water rights of Messrs. Livermore and Chester, as well as some of the other private rights vested or supposed to be vested in some of the settlers on South Fork. The construction of the "Mill" section of the Kern Island Canal was at once commenced, and extended southward about 2 miles, part of the distance following the alignment of the Arujo Ditch. Above this section of the canal the South Fork channel was enlarged, and some systematic effort was made to keep up the supply of water from the river. For the settlers on South Fork, who had not transferred their rights to the canal company, water was turned down that channel free of expense. About 1877 the upper portion of the South Fork channel was entirely abandoned, being replaced by a canal at higher level—an extension of the Livermore-Chester Ditch, located between the old water way and the base of the bluff south of the river. This new canal section was extended to the head of the "Mill" section, where water was dropped about 6 feet to the original level of that canal branch. Meanwhile the various branches of the Kern Island Canal had been extended southward as demand for water increased, and had reached the vicinity of Kern Lake. In 1875 the Kern Island Canal Company was granted franchises for the distribution of water in Bakersfield, where actual delivery of water through its ditch system commenced in May, 1875.

At the time of the formation of the Kern Island Canal Company the swamp lands to be protected by it against inundation were already considered safe, their reclamation in the sense of preventing overflow being regarded as complete. It was claimed, however, that the State had no right to appropriate the money to the credit of this land in the swamp-land fund to any other purpose than its reclamation, and that reclamation should be construed to mean the making of the land productive. The canal company therefore demanded and received from the State the money to the credit of the lands in question as a contribution toward the cost of the irrigation system. The amount of money thus contributed by the State was between $12,000 and $14,000.

The method of constructing the main branch of the Kern Island Canal, which extends from a point on South Fork about a mile south of Bakersfield southerly to Kern Lake, is not without interest. A 5-foot plow drawn by 40 yoke of oxen was used in breaking ground for this canal. The loosened earth was then spread to right and left by means of a V-shaped scraper, also of monstrous proportions, being some 30 feet long and 12 to 15 feet wide. As soon as sufficient water way was thus created to afford some erosive effect, water was turned into the partial excavation and it rapidly cut out an ample water way.

A. KERN ISLAND CANAL REGULATOR AND WASTE GATE, LOOKING UPSTREAM.

B. KERN ISLAND CANAL REGULATOR AND WASTE GATE, LOOKING ACROSS THE CANAL.

The excessive grade, 6 to 7 feet to the mile, of the finished canal soon caused the erosion to extend beyond desirable limits and threatened disastrous results by persistent encroachment on the canal banks. It therefore became necessary to reduce the gradient of the canal by means of check weirs or drops (as shown in Pl. X, *A*), which were placed one-half mile apart. These check weirs were constructed according to designs proposed by Mr. F. H. Colton, at that time superintendent in charge of the canal, and although very simple in arrangement, they proved to be efficient and satisfactory. Weir boards, generally of 1 inch material, were supported by inclined rafters, usually 4 by 6 inches. The rafters were placed at such angle, preferably flatter than 45°, as would best fit the spacing of the vertical posts supporting the sides of the weir box. The rafters transmitted water pressure by means of inclined supports, 4 inches square, to the floor timbers. The rafters were toed into the sill at the upper edge of the floor of the weir box. The floor itself was constructed of 1-inch material nailed to sills of 4 by 6 inch timber, 4 feet apart, which in turn rested upon mud sills, also about 4 feet apart. The floor of the weir box was placed 1½ feet below the downstream-grade height of the canal bottom, and light sheeting was driven along the upper and lower edges of the floor to depths varying, according to character of soil, from 1½ to 4 feet. Wings were carried into the canal banks at right angles to the direction of the canal. They were supported in part by upright posts, in part by timbers across the top of the structure, which at both ends were allowed to project well into the bank. The length of the wings varied according to depth of canal. Weir boards were permanently nailed to the rafters to the height of the grade of canal bottom above the structure. All other weir boards were loose and could readily be moved by hand. Spaces between rafters were usually 4 feet. A plank across the structure, supported by the ends of the rafters, made a convenient footbridge and afforded access to the several sections of the weir. The cost of these check weirs on the Kern Island Canal is reported to have been about $200 each.

The canal head gate is constructed on substantially the same plan. It has a clear width of 48 feet. A waste gate has been placed in the right bank of the canal just above the head gate.

The diversion of water from the river into the canal is accomplished by an inexpensive extension of the right-bank canal levee upstream for nearly half a mile, and its projection in the form of a very low sand-and-brush dam diagonally across the southern portion of the very flat, sandy river bed.

The aggregate cost of the Kern Island canal system has been about $200,000.

The canal has a right to 300 second-feet of water, conceded to it by riparian owners, and taking precedence over all other diversions. Its capacity is reported to be 500 second-feet.

Old South Fork.—The delta stream of Kern River known as South Fork supplied water to a few settlers some years before the construction of the Kern Island Canal was thought of. When Colonel Baker, in 1864, undertook the construction of a levee for protection against overflow, a gate was put into the South Fork channel for the control of its flow of water. The freshets of 1867–68, which produced marked changes in the character and alignment of the main channel of Kern River, filled the head of South Fork with sand. Organized effort was necessary to reestablish a connection of the upper end of the South Fork channel with the river. It is reported that from thirty to forty persons contributed time and labor to this work, the result of which was not, however, entirely satisfactory. The river channel had been deepened; the new cut to the river was nearly half a mile below the original head of South Fork, and great difficulty was experienced in

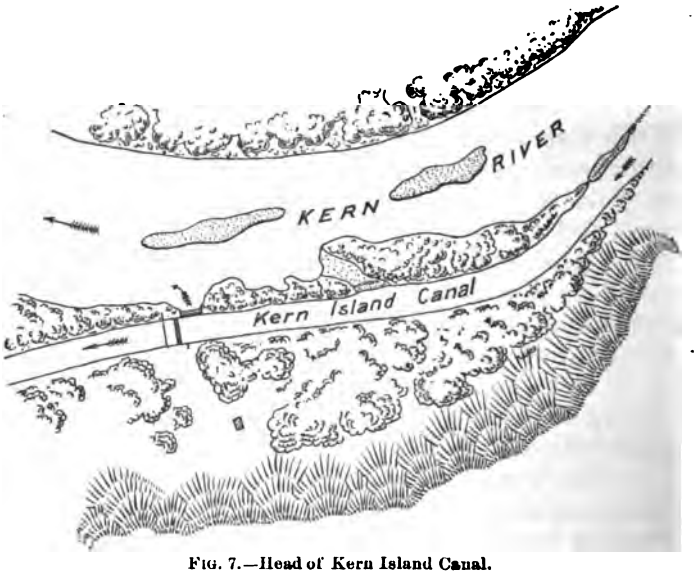


FIG. 7.—Head of Kern Island Canal.

maintaining an artificial barrier at the head of the new channel to turn river water into it. This difficulty led to the construction of the Livermore-Chester Ditch, as already explained, and for a number of years the supply of water to South Fork was through this ditch. About 1877 the use of the upper portions of South Fork was abandoned by the Kern Island Canal Company, and the delivery of water by this company to the irrigators from South Fork ceased. The users of water from South Fork and from Panama Slough resumed control of its head works, and have since maintained this channel as an independent irrigation ditch. A new connection with the river was established near the original head of South Fork, and with more or less trouble it has been kept in efficient service. The management was almost without system, and corporate organization of the owners was not effected until 1885.

A. CHECK WEIR OR DROP ON KERN ISLAND CANAL.

B. KERN RIVER AT HEAD OF SOUTH FORK.

Through the upper portion of South Fork water can be supplied to the lower levels of the Kern Island Canal; Panama Slough is fed with water from South Fork, and as the lower portion of Panama Slough is used as a water way by the Farmers' Canal, there is such interdependence between these several canals, complicated by the fact that many irrigators hold rights to water from two or more of them, that segregation of areas dependent upon any one of them is out of the question.

The principal distributaries of South Fork water are the Jewett Ditch, the Cotton Ranch Ditch, and smaller ditches of landowners in the immediate vicinity of Bakersfield. The capacity of South Fork is generally stated at 50 to 75 second-feet, and the amount annually expended for maintenance is about $1,250. The first cost of the irrigation works can be stated only approximately. It is likely that $3,000 to $4,000 have been expended on construction work.

Farmers Canal.—In 1873 a canal about 50 feet wide and 3 feet deep was excavated from a point on the south bank of Kern River just above the Southern Pacific Railroad, in a southeasterly direction, to a connection with a natural channel known as Cotton Ranch Slough or Skyles Slough. This canal is known as the Farmers Canal. Its water, delivered into Cotton Ranch Slough, flows therein 1½ miles to Panama Slough, and is distributed by a number of small branch ditches throughout the central and southern portions of Kern Island. The canal proper is only about a mile in length. It has recently become of considerable importance as a source of supply for the Stine and Anderson canals, which formerly received their full supply directly from Kern River at the head of Old River, about 3 miles west of Bakersfield.

In 1880 Messrs. Celsus Brower and Walter James estimated the total cost of construction of this canal and its branches at $18,800.

Panama Slough.—Panama Slough hardly deserves separate enumeration among the irrigation works from Kern River, because it is now supplied with water through the head of South Fork. It was, however, in use as an independent source of supply before permanent connection between it and the South Fork channel was established by the freshets of 1867–68. Irrigators dependent upon the flow of water in Panama Slough united with those on South Fork in 1868, when it became necessary to reestablish a connection of these streams with the main channel of the river. All of that portion of Panama Slough below Bakersfield is used jointly by the irrigators who depend upon the Farmers Canal for their supply and by those who hold rights as original users of water from the slough itself.

The principal distributary of the Panama Slough water is the Panama Ditch, the cost of which Mr. Celsus Brower in 1880 reported as having probably exceeded $6,000. The main distributing ditch and branches were then reported to have an aggregate length of 8 miles. Its width was given as 10 feet and its depth of channel as 2 feet.

Castro Ditch.—A comparatively unimportant irrigation ditch which for many years diverted water from the south banks of Kern River at the head of Old River is known as the "Castro" or "Mexican" Ditch. It is reported to have been in use as early as 1859, at that time supplying water to the lands of a few Mexican settlers. This ditch is about 16 feet wide, 2 feet deep at its head, and about 5 miles long. Its capacity is generally rated at about 15 to 20 second-feet, and there may have been expended upon it from $2,000 to $3,000. The head works of the canal, or rather the point of diversion from the river, has within the last few years been extended upstream about a quarter of a mile from the original intake.

Fisher & Abley Ditch.—About 1869 a small ditch known as the Fisher & Abley Ditch was constructed, paralleling the Castro Ditch, and delivering water into Reeder Slough, thence into Panama Slough, from which it was again diverted, a few miles below, for use upon several small farms. That portion of the ditch above Reeder Slough has been abandoned and the lower portion has become dependent upon the Farmers Canal for its supply of water.

Stine Canal.—This name has been applied to portions of Old River and several distributing canals since 1873. In that year the settlers along this river channel united in the construction of a weir about 175 feet long across the head of Old River, and two main branches of the canal were subsequently diverted from this stream. The first one of these, in order downstream, is known as the Call Branch, or Branch No. 1. It has its head about three-quarters of a mile below the head of Old River, is 20 feet wide for about a mile, then 30 feet wide, gradually contracting again to 25 feet. The original depth was intended to be 3 feet, but the channel was made somewhat deeper. One of its branches connects with a branch of the Kern Island Canal. Branch No. 2 of the Stine Canal is diverted from Old River about 5 miles below its head. It is about 6 miles long. The diversion of water from the channel of Old River into these branches is accomplished by means of weirs or regulating gates that serve to control water elevation.

The water passing the head of Branch No. 2 flows on toward the lakes and is occasionally used for wild flooding of grass lands. Recently the diversion of water for the Stine Canal was made through the head of the Farmers Canal and delivered to the former through a canal section called the extension of the Stine and Anderson canals. The capacity of the Stine Canal is claimed to be about 200 second-feet.

The cost of the works, including repairs, was estimated for the principal owners in 1880 at $87,000. This does not include the extension to the Farmers Canal, which was made subsequent to that time.

Anderson Canal.—This canal, which is also called the "Baker & Noble Canal," was constructed, in part, at least, in 1872. The diversion of water for it was originally made from the south bank of New Kern River, about one-quarter of a mile below the head of Old River; but as

ownership of a number of canals became centered in the same group of owners, it was thought desirable to establish common head works for this canal together with the Stine and Castro canals, at the head of Old River. It was therefore extended to this point, and for many years one system of works served to divert water for all three of these canals. Within the last few years a further consolidation of canal head works has been effected, and the water for the Stine and Anderson canals is now diverted from the river through the upper section of the Farmers' Canal, as already explained. The Bellevue property, one of the many possessions of the Kern County Land Company (J. B. Haggin, principal owner), is the locality where the water of the Anderson Canal is used.

Gates Canal.—This canal is reported to have been constructed in 1872 and 1873. It was enlarged in 1874 from a bed width of 9 feet to 12 feet. Its water is used only on the Bellevue Ranch. Its diversion is made about three-quarters of a mile below the head of Old River. It is only 2 to 3 miles long, and its capacity is 30 to 40 second-feet.

Buena Vista Canal.—This name has been given to one of the delta channels of Kern River, together with its system of distributary ditches. The natural water course referred to broke out from the south bank of Kern River about 2 miles below Old River. It was provided with a head gate 26 feet wide in 1870, and a new connection with the river was established. For some years thereafter the settlers along this slough, which had a southerly course, and along its main branch, Button Willow Slough, made use of the water thus admitted under control, for irrigation purposes. Diversion from the sloughs was effected by means of temporary brush dams. In 1875 the canal proper was constructed. The slough was permanently closed about a mile below its head, and its lower section was replaced by the artificial channel of Buena Vista Canal. The capacity of the canal is probably between 100 and 150 second-feet. The cost of works and repairs to 1880 was estimated for the owners by Mr. W. R. Macmurdo at $26,000. A weir of the ordinary light flashboard type is maintained in Kern River just below the head of the James Canal to force water into the Buena Vista and James canals.

James Canal.—This canal was constructed for the irrigation of the odd-numbered sections of land westward from Old Kern River on Kern Island. The construction work commenced late in 1871. The diversion of water from the river is made a few rods below the head of Buena Vista Slough. As originally constructed the canal was 100 feet wide for about 1,000 feet, thence 20 feet wide for a distance of 300 to 400 feet, and 30 to 40 feet wide throughout the rest of the first three-quarters of a mile of its course. Its fall in this distance is 2 feet, and it is intended to carry water 3 feet deep. The length of the main canal is about 18 miles, but its lower portions have fallen into disuse on account of the abandonment of Lake Ranch, where an unsuccessful attempt was

made to irrigate strongly alkaline land. Mr. W. R. Macmurdo, about 1879, estimated the total expenditure on the canal at $16,000. The river weir at the head of the James Canal serves to force water into this canal as well as into the Buena Vista Canal. It is in type similar to the Pioneer weir.

Plunkett Ditch.—This ditch was constructed in 1873. It diverted water for the river about three-quarters of a mile below the head of Buena Vista Slough, and had a southwesterly course. It was made 12 feet wide and 2 to 2½ feet deep, and its length was about 4 miles. Some years later a connection with the James Canal was established, and the Plunkett Ditch may now be regarded as a branch of the larger canal.

Meacham Canal.—The Meacham Canal is one of the small ditches taking water from the south side of Kern River just above the Pioneer Bridge, about 6½ miles west of Bakersfield and about 5½ miles below the head of Old River. It was constructed in 1873. Its length was only 3 to 4 miles and its width 8 to 10 feet. The depth of water to be carried was 2 to 3 feet. The canal is now arranged to deliver its water into the James Canal, with which it has been connected.

Wilson Canal.—The head of this ditch, which was constructed in 1874, was originally located about one-quarter of a mile below the Pioneer Bridge, but in 1875 the ditch was extended upstream to a point alongside the head of the Meacham Canal, just above the bridge. The ditch is only 1 to 2 miles long, about 5 feet wide, and 2½ feet deep.

Henley and Frazier ditches.—These are two small diversions from the south side of the river, about 4 miles below the Pioneer Bridge. The former was constructed in 1874, the latter in 1873. Each is about 2 miles long. Their combined capacity was probably less than 20 second-feet. No information is available as to whether they are still in use.

Beardsley Canal.—The head of Beardsley Canal is about 1½ miles above the head works of Kern Island Canal, on the north side of Kern River. It is the uppermost of the Kern River canals which divert water from this river for the irrigation of portions of the main east-side plain of San Joaquin Valley. The construction of the canal extended through several years, commencing late in 1873. Its course for about 100 feet near its head is along the base of an almost vertical bluff of cemented gravel, and about 2 miles below its head it lies in an extensive cut, 8 or 9 feet deep, through a second bank of cemented gravel. This cut is nearly half a mile long. Otherwise the canal is located on ground favorable for canal construction. The canal was planned to follow a grade line skirting the southwestern base line of the Sierra Nevada foothills, and in this respect differed materially from the works on the other side of the river, which, except the upper section of the Kern Island Canal, were all constructed in the direction of the greatest fall of the land, thus occupying positions which are usually assigned to laterals. The Beardsley Canal was originally made 15 feet

wide and 2 to 2½ feet deep, but owing to the light grade on which it was constructed—0.8-foot fall per mile—it was found difficult to keep it reasonably free from obstruction by the rapidly growing vegetation, and it became necessary to enlarge the canal to make its fall more effective. A timber weir of the open flashboard type is maintained across the river at the head of Beardsley Canal. For many years the full length of this canal was about 8 miles, but as it, with the majority of the other Kern River canals, came into possession or under control of the same owners, the Kern County Land Company, it was extended northward to and across Poso Creek, and now has a total length of about 25 miles. Its laterals frequently extend westward to a connection with the McCord Canal and to the Calloway, so that surplus waters are readily delivered to these lower canal systems. The territory commanded by this canal, lying between it and the Calloway, is about 33,000 acres, which includes between 6,000 and 7,000 acres formerly served by the McCord Canal.

McCaffery Ditch.—The mention of the McCaffery Ditch as an independent irrigation work is merely historical. It is a small ditch diverting water from the south side of the slough known as McCaffery or Calloway Slough, which has been made a part of the well-known Calloway Canal. The ditch is several miles long, 7 to 8 feet wide, and 2 to 3 feet deep. It was constructed in 1873, and is still in use as a distributary of the Calloway Canal water. The use of its water is confined to the island lying between Calloway Slough and the main channel of the river.

McCord Canal.—This canal, which has a position intermediate between the Beardsley and Calloway canals, was built, in part at least, in 1875 and 1876. A diversion of water was made from the north side of Kern River, about 2 miles below the head of the Kern Island Canal, into a natural high-water channel, and from this natural channel the canal proper was carried 3 or 4 miles northward. In 1879 the canal was reported to be about 4¼ miles long, with three branches, aggregating 10 miles in length. Its bed width was noted at 20 feet and its depth at 2 to 3 feet.[1] The canal was provided with a new head gate in 1882 and was extended northward. The main canal had a total length of about 12 miles. The district commanded by the canal is now served with water from the Beardsley Canal, and no attempt is made to maintain the McCord Canal as an independent work.

Calloway Canal.—This is the principal canal for the irrigation of lands on the north side of Kern River. Its purpose was primarily to supply water for the reclamation of lands entered as desert claims. Almost as soon as the notice of intention to make the diversion of water for this canal had been posted at the head of McCaffery Slough, in the spring of 1875, all individual rights were assigned to the Calloway Canal Company, known on the records as the Kern River Land

[1] See Rept. State Engineer, Wm. Ham. Hall, 1880, Appendix to Part IV, p. 77.

and Canal Company, and no time was lost in commencing construction, which was pushed forward rapidly until Poso Creek had been crossed by the main line of the canal. The diversion from the river was effected at the head of McCaffery or Calloway Slough, which was corrected in alignment so far as necessary and cut to a uniform width of 120 feet. The upper 2½ miles of the slough were thus appropriated for canal purposes. Thence an artificial channel 60 feet wide on the bottom was cut in a northerly direction. At between 2 and 3 miles from

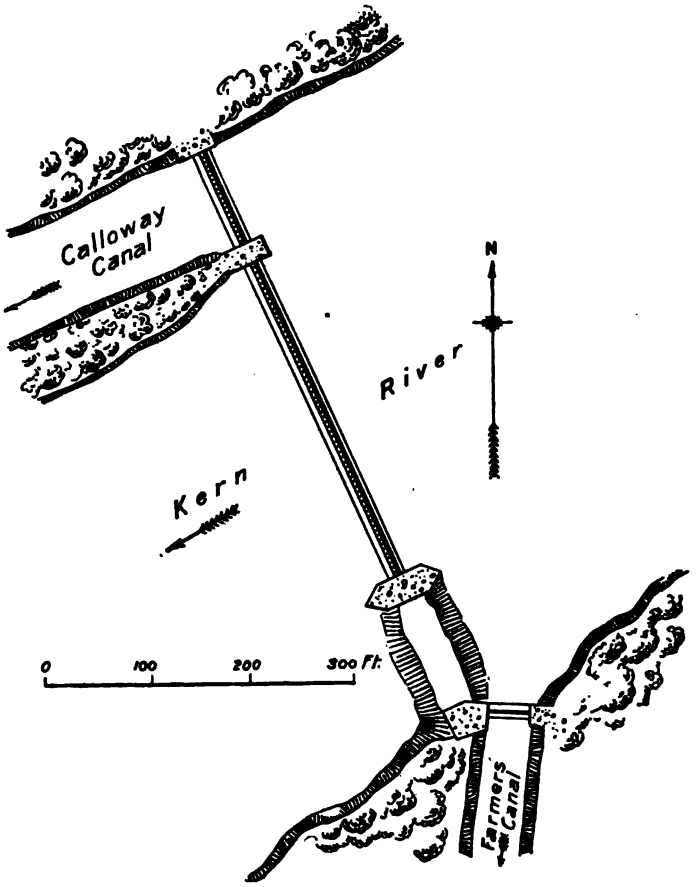


FIG. 8.—Head of Calloway Canal.

the slough the width of the canal was increased to 80 feet on the bottom, and it retained this width to Poso Creek. To the north of Poso Creek the canal extension is 60 feet wide. The canal has a fall of 0.8 foot to the mile northward from the point where it leaves McCaffery Slough for a distance of about 15 miles; thence to and beyond Poso Creek the fall per mile is only 0.4 foot. The total fall from the head of McCaffery Slough to the point where the canal proper leaves the slough is about 10 feet. The inflow into what is ordinarily called

WEIR AND REGULATOR, HEAD OF CALLOWAY CANAL.

the head of the canal, being the original head of McCaffery Slough, is controlled by a head gate or regulator. Where the canal proper leaves the slough a check weir, serving the purpose of a waste gate, closes the latter and affords convenient control of the water-surface elevation at that point. A second regulator is put into the head of the artificial channel, which leaves the slough just above the check weir. Sands accumulating in the slough channel above the lower barrier are readily sluiced out by removing the loose flashboards of the weir and permitting a free flow through the lower section of the slough back to the river.

The distribution of water from the Calloway Canal is effected by means of branch ditches or laterals, which are generally carried westward in the direction of the greatest slope of the valley plain. Their position is usually determined by that of gentle swells or ridges, which afford the best command of the lands to be irrigated. These laterals are ordinarily about 16 feet wide. Their banks are made high, so that inundation of adjacent territory can readily be accomplished. The natural fall of the valley surface in the direction of the laterals is 7 to 20 feet to the mile. This is reduced by means of check weirs or drops to less than 2 feet, effective, to the mile. Tenants of land to be irrigated from these laterals are reported to have frequently taken contracts for their construction as low as 5 cents per cubic yard of earthwork.

Late in 1879 Mr. F. R. Fillebrown, engineer in charge of canal construction, reported an expenditure of $78,165 on the main canal, and $49,460 on about 64 miles of laterals. The area covered by the 64 miles of laterals was reported at 16,160 acres, and the cost of laterals, with gates complete, per acre under ditch was $4. The cost of constructing check levees in this district for irrigation by flooding was given at $2.15 per acre. Water was first turned into the Calloway in 1875, but at that time the principal purpose was to moisten the canal bed and thereby facilitate excavation.

All structures on the canal are extremely simple, but efficient. The head gate or regulator now in use was constructed in 1884, late in the season, after a first freshet had floated the original head gate out of place. The gate was designed and built by Mr. L. F. Colton. While work on it was in progress a large portion of the dam or weir across the river at the head of the canal was washed away, and this was replaced under some difficulty, as the river rose before work was completed and flooded the foundation pit. Much of the flooring had to be nailed under water. The weir or dam across the river is a very light structure, of the open type, resting upon a floor which is the top of a large sand box extending across the river. The weir proper consists of a set of rafters, 4 feet apart from center to center, supported by a set of shores or braces, forming a light framework, and the necessary flash or drop boards for the closing of the spaces between rafters. The rafters were

originally inclined at an angle of about 40 degrees, but when it was found desirable to raise the weir crest somewhat they were placed more nearly erect. They are cut off horizontally at the top and afford support to a single-plank footbridge, each plank of which is held in position by a dowel in the top of the weir timber. This arrangement was adopted to secure a proper spacing of the weir timbers at their tops. The drop boards are of light, 1-inch thick material. According to the original design, the entire superstructure was movable. A set of brackets has been attached to the weir frames below the footbridge to support the drop boards, which are out of service. The total length of the weir was originally 500 feet, of which only the northernmost 400 feet was rebuilt in 1884; the rest, extending from a small island in the river to the south bank, has been replaced by a solid earth, or rather sand, fill. This part of the weir had a superstructure of a type different from

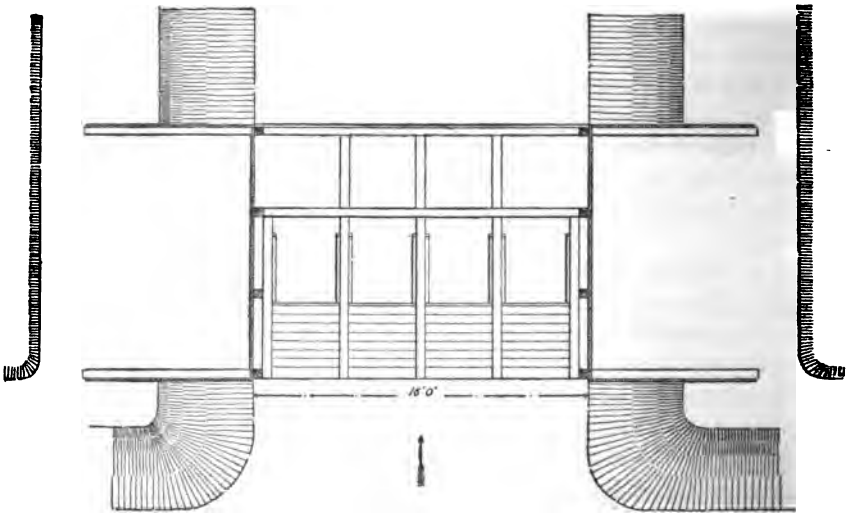


Fig. 9.—Plan of head gate of Calloway Canal.

that of the new weir. Its floor of 2-inch planking rested upon two lines of sheet piling, and the floor joists received additional support from intermediate piles. The river bed at that point, to an unknown depth, is a clean, moderately fine sand, with which all voids under the flooring were compactly filled.

With some variations in detail of construction the river weir is prolonged in a direct line northerly across the head of the Calloway Canal; but the timbers of the Calloway Canal regulator are somewhat heavier than those of the weir. Its frames are not movable. The main timbers are 6 by 8 inches, and have several supports each 6 by 6 inches. The canal regulator is 100 feet long, having 25 openings, or bays, each 4 feet from center to center of gate frames. The drop or flash boards are 1 by 6 inches.

A. CALLOWAY CANAL.

B. IRRIGATING ALFALFA IN CONTOUR CHECKS.

At each end of the Calloway weir and of the canal regulator the banks are protected by timber bulkheads, sheet piling, and brushwork.

A full flow of water is expected in the Calloway Canal during the months February to May, inclusive. At the low stage of the river the canal is entirely dry. The maximum capacity of the canal, estimated some years ago from dimensions below McCaffery Slough, was about 550 second-feet, but the ordinary full flow is 450 to 500 second-feet. More water than this in the canal renders liability of breaks in the banks too great.

The canal laterals have been extended throughout a district having an area of about 60,000 acres, nearly all of which may be considered fully prepared for irrigation and actually irrigated each season. The principal crop irrigated is alfalfa. A view of a large field of this forage crop being irrigated by means of contour checks on the Jackson Ranch is shown in Pl. XII, *B*. No water was sold from the Calloway Canal

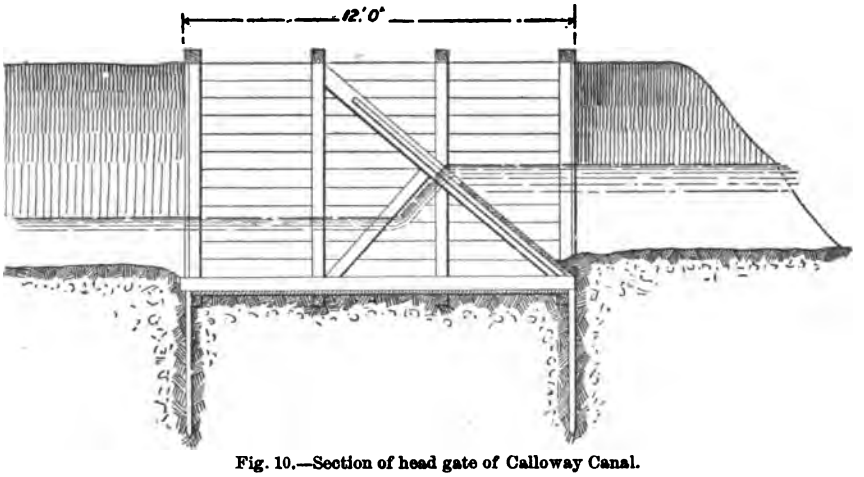


Fig. 10.—Section of head gate of Calloway Canal.

until the sale of lands owned by the Kern County Land Company (J. B. Haggin and Lloyd Tevis) commenced.

Emery Ditch.—This is a small ditch making a diversion of water from the north side of Kern River about 4 miles below the head of the Calloway Canal. It was constructed in 1877 as a private ditch by Mr. R. K. Emery, and was only 3 miles long, 6 to 8 feet wide, and 2 feet deep. The diversion of water was effected by inexpensive brush wing dams, a new one being required after each freshet. Notwithstanding a capacity of 10 to 20 second-feet, but little irrigation was ever accomplished with this ditch. It was difficult to force the necessary water into the ditch even at moderately high stages of the river; the loss of water in transit to lands to be irrigated was considerable, as the route of the ditch was across a sandy region, and the drifting sands made it difficult to keep the ditch open.

Jones & Tuckey Ditch.—The description of this ditch, like that of a number of the other lesser irrigation works from Kern River, is hardly more than a historical note. The ditch was next below the Emery Ditch, on the north side of the river, and followed a parallel route northward. It was about 10 feet wide and 4 miles long. It was constructed in 1876, but fell into disuse seven or eight years later, when it came under control of the principal owners of the larger canals commanding the same territory. Its rights have been merged with those of the larger canals.

Railroad Canal.—At the head of a natural high-water or overflow channel on the north bank of Kern River, known as Goose Lake Slough, three cuts have been made to afford a greater inlet capacity to the head of the slough. The uppermost of these is known as the Railroad Canal. It is about one-half mile long and 25 to 30 feet wide on the bottom. This canal, if such a designation may be applied to the diversion, was constructed late in 1875, and a light timber barrier 40 feet wide (8 bays, each 5 feet) was placed across its head for the control of its flow. The water diverted from the river into this channel was for the irrigation of lands (desert-land entries) near Goose Lake Slough belonging to persons who had failed to secure rights in the Goose Lake or the Wible canals. Very little irrigation was accomplished with it, except the natural wetting of lands adjacent to the slough. Only 320 acres of the lands for which water was claimed through the Railroad Canal are said to be still served with Kern River water.

Wible Canal.—Just below the Railroad Canal is another cut from the river to the slough, which was made in the summer of 1875, by another set of persons, who were desirous of using Goose Lake Slough as a main channel to carry water to their lands. This cut was only 1,000 to 1,500 feet long. It was 30 to 35 feet wide on the bottom and about 2 to 3 feet deep. Its head gate was 56 feet wide. The first cost of the canal is reported at $3,500, and the cost of the regulator at $500. Water is apportioned to stockholders without any elaborate system of measurement. Expenses of management, which are light, are apportioned to the consumers of water by mutual agreement.

Goose Lake Canal.—First in the order of time of construction, but third in position, is the enlarged original head of Goose Lake Slough, known as the Goose Lake Canal. This is located on the north side of Kern River just above the Pioneer Bridge, about 7 miles in a direct line west of Bakersfield. In 1874 the head of Goose Lake Slough was cleaned out and enlarged and a regulator was built across it. This regulator is 134 feet wide. The head of the slough was 150 to 160 feet wide. This work has always been under the control of the parties who controlled the principal large canals already enumerated and has not been in use to any considerable extent for systematic irrigation.

A. PIONEER CANAL WEIR, KERN RIVER.

B. PIONEER CANAL.

Pioneer Canal.—This canal was constructed in 1873 by settlers upon lands on the north side of the river below the Pioneer Bridge. It was originally made 30 feet wide at its head for a distance of a little over 100 yards; there its width was decreased to 10 or 12 feet. Subsequently, however, the canal was enlarged to a bed width of 30 feet throughout a length of 7 or 8 miles, and its upper sections were still further enlarged in 1879, when the canal was made 60 feet wide. From its head at the Pioneer Bridge the canal has a westerly course, its waters being used principally upon the Kern County Land Company's tract of land. The canal capacity reported for this canal by Mr. W. R. Macmurdo, C. E. (in charge of canal work in 1880), was 450 second-feet, and its cost about $44,000.

The head gate of this canal offers some points of interest. It rests upon sand. A trench was excavated across the canal, 14 feet wide

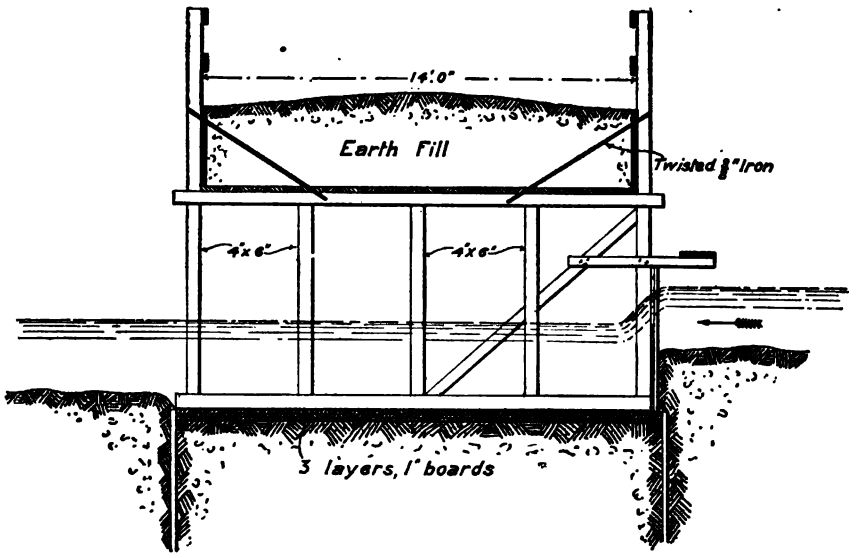


FIG. 11.—Section of Pioneer Canal regulator.

(14 by 60 feet) and 3 feet deep. Light sheet piling was driven on the four sides of this trench 1 foot deep. To the top of the sheet piling were nailed 2 by 4 inch timbers at the height of the canal grade. The trench was then refilled and 1 by 6 inch pine boards were laid across the top of the filling 4 feet apart, in the direction of the canal axis. Floor boards 2 inches thick were thereupon nailed to the pine strips and extended over the side walls of the trench. They were laid across the axis of the canal. On this floor sills 4 by 6 inches were placed on edge, 4 feet apart, for the support of 4 by 6 inch posts, which serve as bridge posts. The bridge floor is 2 inches thick and covered with an earth fill 3 feet thick, which serves to give weight and stability to the entire structure. The sides of the bridge, acting as retaining walls for the earth fill, are tied to the floor joists by means of three-eighths-inch

iron rods, twisted together for tension. The upper bridge posts support the loose flashboards by means of which the structure is converted into a regulator. This is one of the best examples of a cheap, efficient structure. Its total cost was only $540, including all earthwork. It was built in 1884 by the engineer in charge, Mr. Walter James. The weir in the river at the head of the Pioneer Canal was originally a combination structure. The weir posts supported a bridge, toward the construction of which a money contribution was made by Kern County. The original weir has been replaced by a late structure, crossing Kern River just below the Pioneer Bridge. This is very similar in arrangement to the one at the head of the Calloway Canal. It controls the water-surface elevation in the river for a number of canals and ditches besides the Pioneer Canal, including the Goose Lake Slough system on the north side of the river, and the Wilson and Meacham ditches on its south side.

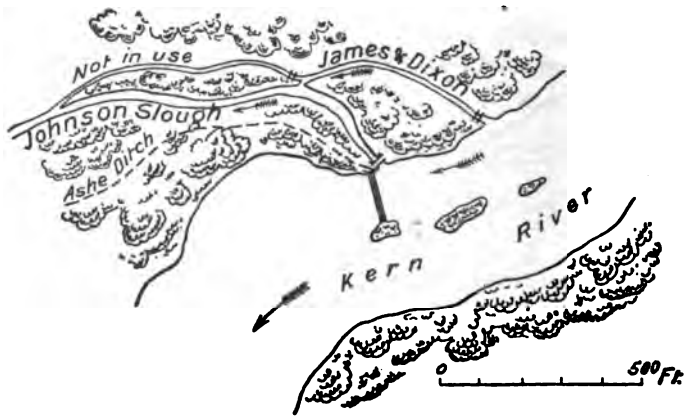


FIG. 12.—Head of James & Dixon Canal.

Edwards Ditch.—This ditch, whose head is about a mile below the Pioneer weir, is to be classed with those of lesser importance. It was constructed in 1875. Work may have commenced late in the preceding year. The ditch was about 2 miles long, and 10 to 12 feet wide on the bottom. It fell into disuse in 1879, but was reopened in 1885. It was then in use by several persons, but received water only at high stages of the river.

James & Dixon Canal.—This name has been applied to a cut about 2½ miles below the Pioneer Bridge, from Kern River into Johnson Slough (one of the river's north-side delta channels). This cut was excavated in 1872 and 1873. It was less than half a mile long, and was originally made 30 feet wide on the bottom. In 1884 it was connected, at a point about 200 yards below its head, with the Johnson Cut, a second opening from the river into Johnson Slough. The water delivered into the slough by the James & Dixon Cut is for use on portions of the McClung Ranch and on the Buena Vista Ranch. The slough is

used in common by the owners of the two canals for about a mile below the point where their waters are mingled. The Johnson Canal water is there taken out of the south side of the slough for distribution to irrigators, while the James & Dixon Canal water flows on down the slough channel.

About 1882 it became necessary to establish a better control of the flow of water into Johnson Slough. To this end a reasonably permanent wing dam was constructed just below the Johnson Cut, and a new head gate, or regulator, was placed in that cut. The wing dam was in the form of a timber weir extending halfway across the river channel and resting against a small island. The space between its end and the south bank of the river was closed annually at the low-water stage by an inexpensive sand dam. The water was thus forced over the weir and brought under control. The control at high stages was not essential. This work was carried out under the direction and management of the owners of the James & Dixon Canal, and a proportional part of the cost—$2,200 out of a total of $4,700—was contributed by the owners of the Johnson Canal. The water supply for both canals was thereafter drawn through the same regulator.

The original purpose for which the James & Dixon Canal was constructed was to supply water for irrigation to the Buena Vista Ranch, then owned by Mr. James Dixon, and to lands in its vicinity. The canal and the lands to be irrigated by it have long since become a part of the property under control of the Kern County Land Company.

The combined capacity of the James & Dixon and the Johnson canals has been estimated at 400 to 450 second-feet. The head works of the James & Dixon Canal are now out of service, because it has been found more convenient to supply water to the lower section of the canal through a branch of the Pioneer Canal.

Johnson Canal.—Several hundred feet below the original head of the James & Dixon Canal is the cut from the river to Johnson Slough known as the Johnson Canal, which is owned by the Lower Kern River Irrigating Company. It was constructed in 1873 and is about one-eighth mile long. It was described by Mr. James D. Schuyler, in his report to the State engineer, as being 10 feet wide on the bottom, 3 feet deep, with bank slopes of 1 on 2; but greater original dimensions are claimed for it by resident engineers of Kern County. The canal water, as already noted, flowed about a mile in Johnson Slough and was then taken out for delivery to irrigators. The separation of its water from that of the James & Dixon Canal was effected and controlled by means of regulators, one being placed in the slough, another in the artificial channel. There was no sale of water to consumers. The canal owners took water as they needed it, and expenses of canal management were apportioned. The cost of maintaining head works at the river was borne in part by the owners of the James & Dixon Canal. Water is now delivered to the lands served by the Johnson Slough Canal

through branches of the Pioneer Canal, and the use of the canal head works has been abandoned.

Ashe Ditch.—This ditch, which fell into disuse about 1882, was a small one, belonging to a private owner, and was constructed about 1874 or 1875. Its head was on the north side of the river, just below the Johnson Canal. It had a westerly course, was about 1 mile long, 8 feet wide on the bottom, and 2 feet deep. Its mention is merely historical.

May Ditch.—This ditch was in use for several years subsequent to 1874. Its length was 2 miles, its course westerly, its width about 8 feet, and its depth 2 feet. Its head works were 4 to 5 miles below those of the Johnson Canal. Whether it is now in use is not known.

Joice Canal.—There is some confusion among names applied to the ditches of Lower Kern River which were intended in whole or in part to supply water to the Buena Vista Ranch. In 1873 the lands known by this name were owned by the late W. C. Ralston, and were under the management of James Dixon. The first diversion made for their irrigation was in that year, from a minor north-side delta channel of the river known as Gage Slough. The ditch was 12 feet wide, and was intended to carry water about 2 feet deep. To increase the flow of water in that branch of Kern River upon which Gage Slough was dependent, a dam of brushwork was constructed across the most southerly of two channels into which the river separated a short distance above the head of Gage Slough. Still later, in the same year, a second ditch was constructed from the north side of the river above the slough, and this was connected with the first ditch. The head of Gage Slough was then closed permanently.

Two years later a private ditch was constructed as a branch of the Joice Ditch, commencing about 2 miles below the head of the latter. This was known as the Dixon Ditch, and has led to the use of the name Joice & Dixon Ditch for that part of the original Joice Ditch above the Dixon Ditch. The uncertainty as to amount of water covered by recorded claims, and the procedure in Kern County leading to the granting of a canal franchise, are well illustrated by the Joice Canal. A notice was posted on April 28, 1873, in sec. 21, T. 30 S., R. 25 E., Mount Diablo meridian, by Messrs. E. V. Joice and James Dixon, of a claim to 10 cubic feet of the water of Kern River, measured under a 4-inch pressure. On May 26 of the same year the same persons posted another notice of claim to 20 feet of water, measured under a 4-inch pressure. These claims were followed in 1878, on October 7, by another by Mr. William B. Carr, posted on sec. 23 at the head of Joice Canal, to 6,250 inches of water, measured under a 4-inch pressure. He was on the following day granted a franchise by the supervisors of Kern County, acting in the capacity of water commissioners, to construct a new canal 30 feet wide on the bottom, 2 feet deep, and having a cross-sectional area of 72 square feet, or to enlarge any canal acquired by

him to these dimensions for the purpose of diverting the amount of water named in his claim. The franchise then obtained was transferred a few days later to the Joice Canal Company.

From a report made in 1879 by Mr. W. R. Macmurdo, one of the engineers in charge of canal work, to Messrs. Haggin & Carr it is learned that the cost of irrigation with water of this ditch, after ditches and checks were all constructed, was as low as 10 cents per acre. The lands commanded by the canal can also be supplied with water from the Pioneer Canal and from the James & Dixon Canal, as has been already explained. The Joice Canal receives water only during comparatively high stages of Kern River. A timber weir extending partially across the river was maintained for a number of years, but it has recently been found more convenient to abandon the canal head works and to supply it with water from the Pioneer Canal.

Dixon Canal.—Two years after the construction of the Joice Canal the branch known as the Dixon Canal was carried in a northwesterly direction, for the irrigation of a small tract of land on the margin of the lands segregated as swamp and overflowed, and thereafter the upper portion of the Joice Canal, about 2½ miles long, was regarded as the common head of the two ditches. The ditch was described by Mr. James D. Schuyler in 1880, in his report to the State engineer, as being 2½ miles long, 6 to 8 feet wide on the bottom, and 1½ feet deep.

Kern Valley Water Company's canals.—For the reclamation of the lands in the upper or southeastern portion of Buena Vista Swamp two large canals were constructed, one upon either side of the long, narrow trough of the valley through which the overflow waters of Kern and Buena Vista lakes took a northwesterly course toward Tulare Lake. Of these two canals, the one on the west side was intended as a recipient of the flood flow, and was therefore given magnificent dimensions. The other canal was to serve more particularly as a source of supply for irrigation water. Both of these canals were connected with Buena Vista Slough, a natural channel of irregular alignment and variable dimensions, which has a northwesterly course from Buena Vista Lake for a distance of about 8 miles to the vicinity of the canal head works, near which point its channel becomes more or less indefinite.

At the time these canals were constructed, about 1875, it was proposed by their projectors to convert Kern and Buena Vista lakes into great storage basins of water to serve for the irrigation of lands to the northwest. But this proposition met with opposition. Other claims to the lakes were advanced. The lake beds were claimed as swamp and overflowed land subject to reclamation by drainage. Long litigation ensued, involving among other things the question of riparian ownership in the waters of Kern River, as it was manifestly to the advantage of the owners of lands in Buena Vista Swamp to prevent diversions in the upper sections of the river, so as to augment the flow through natural channels into Buena Vista Lake and thence into the channels

from which the lower canals were fed. As a result of this litigation it was definitely determined that the doctrine of riparian rights prevails in this State; and, more directly bearing upon the questions at issue, it led to an agreement between the conflicting interests according to which the use of lake surface for reservoir purposes was restricted to Buena Vista Lake, and some definiteness was given to the rights of the various canals to make diversions of the Kern River water.

As soon as this result was reached, in 1891, work progressed rapidly on the structures necessary to dam off Buena Vista Lake toward the east and to control the outflow of its waters toward the north. The storage capacity of the lake is represented to be 150,000 acre-feet, being presumably the amount actually available for irrigation purposes when the lake is full. The alignment of the principal channel of Kern River in its course toward the lake has been corrected, and it is separated by means of high embankments from a return channel correspondingly correcting the alignment of Buena Vista Slough. With-

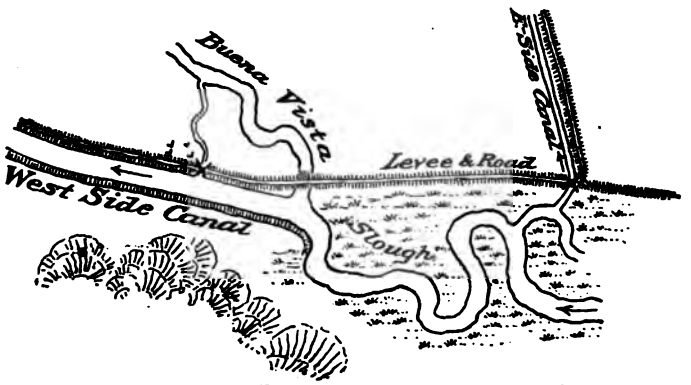


FIG. 13.—Head of Kern Valley Water Company's canals.

out any definite information concerning the cost of these works, it is not unreasonable to suppose that it has exceeded $250,000, in addition to over $300,000 for original canals.

The west-side canal was made 125 feet wide on the bottom and was planned to carry water 7 feet deep. The position of the canal along the western border of the swamp gave it a fall of about 4 to 5 feet to the mile, which was reduced by means of check weirs or drops. Four of these were constructed, but three were washed out, and but a single one remains to serve as a regulator. The canal has a length of 24 miles, covering more than one-half the distance toward Tulare Lake, and discharging at its lower end upon the lower portion of Buena Vista Swamp. The east-side canal is 25 feet wide and has a depth of 3 to 5 feet. A regulator has been placed in it where it is crossed by the road embankment, which serves as a barrier against flood waters of the river or slough from the south. The regulator is a combination of a bridge

with earth fill on top and a gate. The gate is of the ordinary vertical flashboard type.

Where water is to be drawn from the main west-side canal for irrigation purposes it is admitted to distributing ditches by means of wooden box culverts placed under the canal levee.

Maintenance of the works has involved frequent bank protection on the main canal, the bottom of which below its regulator has been irregularly eroded.

Flood waters have frequently made dangerous inroads upon banks and levees where the canal lies in the light alkaline soils of the west side, which do not afford much resistance to the erosive action of the water.

The irrigation from this canal system is still confined to the alfalfa fields at the head of Buena Vista Swamp between the two main canals. Here about 20,000 acres of alfalfa, in one continuous tract and under one ownership and management, represent the extent of the water's use.

The system of irrigation is the contour-check system. The contour levees have usually 6 inches difference in elevation, or a little more. The soil is a black vegetable mold, 4 to 6 inches deep, under which is a heavy clay subsoil. Checks are generally 8 to 10 acres in area. Small checks are preferred, and some of the larger ones are being subdivided. Some drainage of the land after flooding is necessary and drain ditches are provided for the purpose. The cost of preparing the land for irrigation, including the cost of small ditches, was about $10 per acre.

KERN AND TULARE IRRIGATION DISTRICT.

No work of actual construction was done on the proposed canal system for this irrigation district, now disorganized, but as the contemplated source of water supply was Kern River the project requires mention. The district was located on the east-side valley plain surrounding Delano, in Kern and Tulare counties, about 25 miles northward from Kern River. It had an area of 84,000 acres. The proposed main canal was to have a bed width of 40 feet, a water depth of 4 feet, a fall of 9 inches to the mile, and a total length of about 55 miles. The diversion from the river was to be made about 8 miles above the head of the Beardsley Canal, on the north side of Kern River, and the route of the canal was to be westward along the bluffs and broken slopes of the hills for about 7 miles, to where it emerged upon a comparatively smooth plain at the base of the hills, thence northerly across Poso Creek and Dyers Gulch, to and across White River. The estimated cost of the main canal was $426,000 and of the necessary distributaries $195,000. The district was organized in 1890, and a bond issue of $700,000 was intended to cover cost of works.

WATER SUPPLY, DISTRIBUTION, AND MEASUREMENT.

The breadth and shallowness of the bed of Kern River, whose banks are only 3 to 6 feet high, facilitate diversion of its water. The lands irrigated have already been described.

Diversions are numerous both toward the north and toward the south, and are usually effected by the use of light, movable, open-work timber weirs, above which water is forced into the head of a ditch or canal. The flow in the canals is controlled by gates or regulators, usually of the inclined or vertical flashboard type.

The canals on the north side of the river have an aggregate capacity of several thousand second-feet; those on the south side, between 1,000 and 2,000 second-feet.

Most of the Kern River canals were constructed for the irrigation of particular tracts of land, and therefore received alignments as direct as possible from the point of diversion to the land to be irrigated. Their location in a position to command as much land as possible is exceptional. The Kern Island, Beardsley, McCord, and Calloway canals are among the exceptions. On Kern Island the course of the canals is generally in the direction of the greatest slope of the ground's surface. As this slope is represented by a fall of about 7 feet to the mile, and the soil is generally easily eroded, check weirs or drops are necessary to check the flow of water in the canals and to render diversion into laterals possible. Such structures are about one-half mile apart on the principal original branches of the Kern Island Canal. There are 25 of them in the main channel of the Stine Canal, and about the same number on the Buena Vista Canal. The James Canal has 14.

Despite the various names assigned to the Kern River canals and to the corporations which own them, the conflicting interests thereby indicated do not all exist. Almost the entire canal and ditch system of this river has passed into the control of the two great proprietary firms, Haggin & Tevis and Miller & Lux, and contentions as to water apportionment are usually restricted to broad questions affecting whole districts rather than individual diversions. Until a satisfactory allotment of the low-water flow of the river was agreed to by these firms, comparatively little attention was paid to perfecting a system of water apportionment either from the river or from the several canals. It was the rule for each irrigator to use water as he required it, so long as water was available. The only canal from which water was sold until within the last few years was the Kern Island Canal.

The plan of apportionment of water in the case of the Beardsley and the other canals owned by joint stock companies, stock being held by landowners, gave to each stockholder a part of the water in the canal proportional to the amount of stock owned, but the distribution was based on approximation, without attempting measurement of the water delivered.

The allotment of water to the irrigators from the Kern River canals is in charge of canal superintendents, who are assisted by ditch tenders, locally called "zanjeros." The canals are inspected daily, and the water applied for by irrigators is delivered into their irrigating ditches. Water is sold by measurement, being delivered through measuring boxes.

Before 1875 water was furnished free of charge from the Kern Island Canal to irrigators, in order to encourage its use. During the years 1875 to 1877 it was sold at 1¼ cents per 24-hour inch (miner's inch, supposed to be under 4-inch pressure, equivalent to about 0.02 second-foot), aggregating about $1.50 per acre per annum, as then used for the various crops cultivated. In 1878 the rate was increased to 1½ cents per 24-hour inch. In 1879 the Kern Island Canal Company charged the following rates for water:

For general farming: April to November (inclusive), 1½ cents per inch under a 4-inch pressure, for twenty-four hours. December to March (inclusive), 1 cent per 24-hour inch.

For market gardens: For 12-inch stream and upward for not less than one half month, 2 cents per inch per day of twenty-four hours. For 48-inch stream and upward for one day or more, 2 cents per inch per day of twenty-four hours.

For house lots and gardens: 12 inches for one day of twelve hours, or 24 inches for one-half day of six hours, $1; 12 inches for one night of twelve hours, 75 cents; 12 inches for one-half day of six hours, or 24 inches for three hours, 75 cents; 24 inches for one day of twelve hours, $1.50; 24 inches for one night, $1.25; 24 inches for one hour, 50 cents.

The prices now charged vary somewhat for the different canals, being adjusted according to operating expenses. They range from about 30 to 75 cents per second-foot for twenty-four hours, and in exceptional cases have been below the lowest rate named.

The original measuring box was so constructed that a uniform head, over an aperture which could be adjusted to the number of inches called for, could be maintained. The area of the aperture was controlled by means of a horizontal sliding board. It was 4 inches in height, and the surface of water above the aperture was maintained at 4 inches above its top. Water had an unobstructed outfall through the aperture.

This gate was superseded by a well-constructed overfall weir. Water is admitted to a chamber above the weir by means of a gate which affords control of the water elevation. The depth of overfall is determined by measurements to the water surface above the weir from a carefully set "level-board." The cubic foot per second, or second-foot, has recently been substituted for the inch as the unit of measurement. At the present time gates with submerged orifice are preferred and are coming into general use.

On the South Fork Canal no system of measurement has been introduced. Each consumer takes what he requires when there is an abundant flow in the canal. When water becomes scarce, a canal superintendent is employed to apportion the water to the canal stockholders.

The same lack of system in water measurement prevailed for a long time on the Pioneer, the Beardsley, and many other canals before they passed entirely into the ownership or under the control of the large water corporations.

METHODS OF IRRIGATING AND DUTY OF WATER.

Alfalfa and cereals are still the principal crops irrigated with Kern River water, although during a few years orchard and vineyard areas increased rapidly in the colony tracts north of the river. The demand for water for the large areas represented by the alfalfa and wheat fields has led to special effort to minimize the expense of applying water to the soil. The system of wetting the soil for these crops is generally by flooding, which is accomplished in various ways. The most primitive system, rapidly falling into disuse, is that of spreading water over the surface from small temporary ditches, sometimes mere plow furrows, located on high ground, and controlling the overflow from these. Skill is required to cover the whole surface with water; the progress of irrigation is slow and the system is expensive because much labor is required to control the water. The only advantage of this system is that its first cost is small.

Irrigation by flooding in rectangular checks is confined to occasional orchards and vineyards and small tracts of alfalfa. The favored method of applying water is by flooding in contour checks. Low, flat embankments, generally 1½ feet in height, rarely 2 feet, are thrown up, which closely follow contour lines, and the spaces between these are divided into compartments or checks by means of cross levees. The areas of these checks range from less than 1 acre to 60 acres. When a tract of land checked in this way is to be irrigated, water is admitted to the highest checks first, and as soon as the flooding of a highest check is complete its water is drawn off through suitable gates to the one next below, into which the irrigating stream is turned at the same time.

The labor attached to this system of irrigation is much less than that required by the method of wild flooding, but the first cost of preparing land is considerable. The cost of land preparation will of course depend upon the smoothness of the surface and its slope; also upon the character of the levees between compartments. The best form of these levees has a base 16 to 24 feet in width and slopes so flat that any kind of farming implement may cross them in any direction.

The following example of cost of land preparation and ditching under the Calloway Canal has been taken from notes by Mr. James D. Schuyler:[1]

The average cost per acre of 5,956 acres prepared in this way was as follows: Earthwork, $1.64; waste or drainage gates, $0.51; total, $2.15. The average cost of lateral canals, including necessary regulators and side gates to supply the land, was $4 per acre, making the total cost of preparation of ground $6.15 per acre.

These check levees are built upon 1-foot contours with about 20 feet base; the lateral canals are from one-fourth to one-half mile apart, and the checks range from ten to fifty acres in area. From 15 to 20 miles of check levees are required per square mile of land, and a mile of levee contains 3,080 cubic yards. The soil is a sandy loam, easily worked, and the cost of preparation shown above is probably less than the average cost of such works elsewhere.

The laterals can supply water to the checks between them at a rate generally between 100 and 200 second-feet, the amount of water ordinarily admitted at one time into a check being about 50 to 70 second-feet from each of the laterals between which it lies. The contours on which the levees are constructed are from 0.5 to 1 foot apart in vertical elevation. One foot was first adopted as the vertical distance between contours, but experience has proved it to be better to reduce this distance, thereby making the water more controllable and at the same time reducing the area of the checks.

In filling large checks water stands long on the lowest ground. It is customary to draw it off into the next check as soon as the whole surface is submerged. But it is found that the portion of the check submerged for the shortest period of time produces a crop equally as good as that from any other portion. All percolation in localities where water stood more than the minimum time allowed for the high places is therefore a waste of water. This waste in large checks is frequently so great that a check can hardly be filled, as water is lost by percolation almost as fast as supplied. Economy of time and water would therefore seem to demand checks smaller than those in common use at present to the north of Kern River, where the average area of checks is about 8 to 10 acres. Moreover, the use of lower check levees reduces the obstructions offered by the check system to farming operations.

It can be shown by mathematical demonstration that there is considerable loss of water and of time when porous soils are irrigated in large checks, but an example will suffice.

The irrigation of a 60-acre check of alfalfa with water from the Calloway Canal commenced at 5 o'clock p. m. on May 12, 1885. All parts of the check were covered and irrigation was complete about 8 a. m. on the following day. No accidents causing loss of water had occurred. The amount of water entering the check was stated to have been about 250 second-feet (one-half the amount then flowing in the Calloway Canal). This is presumed to be an overestimate, and it will be safe to say that at least the maximum amount ordinarily delivered from two

[1] Rept. State Engineer of California, 1880, Part IV, App., p. 85.

laterals was entering the check. This amount would be about 150 second feet.

During the time required to accomplish the irrigation of these 60 acres the amount of water entering the check was sufficient to have covered it to a depth of over 3 feet, while the amount in the check when its irrigation was complete, and which was in part available for irrigation in lower checks, had an average depth of about 0.75 foot. The total amount absorbed was therefore over 2.25 feet, and it must be presumed that much more water sank into the ground in those parts of the check which were lowest and had water standing on them fifteen hours than in those parts which were highest and were submerged only from two to three hours.

For economic irrigation the volume of water applied and the areas of the checks should be so adjusted that no portion of the check will be under water more than twice as long as the period of desirable inundation. In porous soils the full head of water can generally be allowed to flow into a check until irrigation is complete. In heavy soils there is less danger of excessive waste, absorption by the soil is less rapid, and the head of water may be reduced as soon as the whole surface of the check is submerged. A rapid delivery of the surplus water from an irrigated check into the one next below it is essential to economic irrigation by the contour-check method.

Irrigation from the Calloway Canal in May, 1885, was progressing at the rate of 200 to 400 acres per day. The flow of the canal was 450 to 475 second-feet. In other words, the irrigated tracts were receiving water at the enormous gross rate of 130,000 cubic feet per acre, equivalent to an average depth of about 3 feet over all lands irrigated.

A new system of irrigation by flooding has recently been tried on some of the land commanded by the Calloway Canal. This system consists in the construction of parallel levees which follow lines of greatest slope at short intervals. These levees are low, not over 1 foot high, and are placed 50 to 200 feet apart. There is between each two a long, narrow strip of land, crossed at intervals by a levee at right angles to the embankment on each side. These cross levees have along their bases distributing ditches with gates on their lower sides, so arranged that water can be admitted into the compartment between the levees lying next below. Flooding is accomplished by admitting water in large quantities to a compartment at its upper end and allowing it to flow in a broad, shallow sheet to the lower end. Water not absorbed in thus passing through a check is collected at the upper base of the lower cross levee and is allowed to find its way back into the distributing canals for use at points below. Only land with a smooth surface and of very slight slope can be irrigated in this way. The system is better adapted for alfalfa fields than for grain land, because in the former the surface of the soil is more compact and the plants offer more resistance to the flowing water.

The following examples of irrigation, illustrating the duty of water, are in part taken from Mr. James D. Schuyler's report to the State engineer in 1880.[1] The latter ones are from unpublished data collected and prepared for the use of the State engineer in his final publication, which has not been issued.

In the following table the quantity of water used by some Chinese vegetable gardeners in 1879 from the Kern Island Canal, near Bakersfield, is noted. The data on which the table is based are reliable.

Quantity of water used by gardeners in 1879 from the Kern Island Canal, near Bakersfield.

Name of irrigator.	Area of land irrigated.	Total water used.	Average depth of water used on land.	Cost of water per acre.	Period of irrigation.
	Acres.	*Cubic feet.*	*Feet.*		
Sin Mon	30.0	5,320,800	4.07	$1.97	Dec., Feb. to June (incl.).
Ah Cow	.8	1,331,840	38.20	20.00	Feb., Mar. to June (incl.).
Ah Gee	50.0	6,375,600	3.00	1.42	Jan., Mar. to June (incl.).
Ah Song	3.2	2,751,200	19.70	10.00	Jan. to June (incl.).
Ah Lung	3.2	2,322,432	17.00	6.17	Feb. to June (incl.).
Sing Lee	10.0	1,658,880	3.80	1.92	Apr. to June (incl.).

The smaller of the gardens irrigated have a stream of 6 to 12 inches (0.12 to 0.24 second-foot) running continuously, day and night.

On secs. 1 and 2, T. 30 S., R. 27 E., 2 miles south and west of Bakersfield, along Panama Slough, where the land receives the percolation of several channels, natural and artificial, a field of 50 acres of alfalfa is irrigated in six days and nights with a stream equal to 1½ second-feet, and an orchard of 20 acres is irrigated in two days and one night with the same amount. The discharge would be equivalent to a depth of 0.36 and 0.37 foot, respectively, over the land irrigated. The soil is an alluvial loam. The orchard is irrigated once a month, and the alfalfa field once or twice a year, or more, when it is used as a pasture.

SE. ¼ sec. 30, 6½ miles south of Bakersfield, was irrigated first in 1878. Four acres can be irrigated in twenty-four hours with 7 second-feet. Allowing a loss of 1 second-foot in transit from canal to lands, this amount would be equal to a depth of 3 feet over the whole area. The soil is a sandy loam. Surface water is at a depth of 6 feet, rising to 3 feet after irrigation and subsiding again. The crops irrigated are wheat, barley, beans, sweet potatoes, alfalfa, and orchard and small fruits. The water used in 1878 cost $1.03 per acre, and in 1879 it cost 81 cents per acre.

On SW. ¼ sec. 31, 7½ miles south of Bakersfield, a first irrigation of 40 acres in May and June, 1879, was effected with 1,209,600 cubic feet of water, equivalent to a depth of 0.7 foot over the whole area. The land was thoroughly soaked in the spring by a break in the canal, and received the benefit of constant percolation. Cost per acre of the only

[1] Report of W. H. Hall, State Engineer of California, 1880, Part IV, App., p. 86 et seq.

irrigation given was 25 cents. The soil is a sandy loam containing decayed vegetable matter. Crops, cereals.

On sec. 32, 7½ miles south of Bakersfield, from July 23 to 29, inclusive, six days, 40 acres were thoroughly saturated with a discharge of 7.73 second-feet, equivalent to a depth of 2.3 feet over the whole area. The land had been irrigated but once before this season—the first week of May. It was dry to a depth of 6 inches, while surface water stood at a depth of 3.75 feet below surface. The land was first irrigated in the spring of 1878, when surface water stood at a depth of 17.5 feet. After first irrigation it rose to 12 feet; after first irrigation in 1879 it rose to 3.75 feet, where it remains. The soil is an alluvial sandy loam, mixed with partially decayed tule roots to a depth of 17 feet, and underlain by a stratum of clay 12 to 14 inches thick. The crops are wheat, barley, alfalfa, and corn. The average number of irrigations during the season is about one and a half. The average cost of water per acre is 70 cents. The average cost of labor (Chinese) per irrigation is 8 to 10 cents. A part of the land is irrigated by the check system, and a part by the small ditch or wild flooding system.

On sec. 5, T. 31 S., R. 28 E., 8½ miles from Bakersfield, adjoining the last-named section, with similar soil, and cultivated the same length of time, a record was kept of the quantity of water used for the second irrigation of a tract of 150 acres of corn. The total discharge in twenty-one days was 16,004,736 cubic feet, sufficient to have covered the land to a depth of 2.45 feet. The land had been irrigated in February or March for wheat, but it was so late that only weeds sprouted. In June the land was irrigated again to prepare it for corn, and the last irrigation noted above was from July 23 to August 12. The total cost of labor employed for the last irrigation of corn was $80.50, or 53.67 cents per acre. The total cost for water and labor was $1.20 per acre. The total cost of water used on the section during the season for 350 acres of wheat and 150 acres of corn was $452.32, or 90.5 cents per acre.

On sec. 7, T. 31 S., R. 28 E., the first irrigation of 50 acres of corn (the land having been wet before plowing in May) was accomplished in ten days—July 21 to 30—with an average discharge of 7.2 second-feet, equivalent to a depth of 2.86 feet over the whole area. The total cost for water was 31 cents per acre. The total cost of water for the season for irrigation of 90 acres of wheat and barley, 50 acres of corn, and 70 acres of alfalfa was 55 cents per acre. The soil was in part black, stiff loam, almost adobe in texture, in part loam mixed with sand, and in part coarse sand underlain by quicksand. Most of the land under cultivation was irrigated this year for the first time. The ranch could nearly all be subirrigated, but the owner preferred the small ditch system. He thinks that next year his land will absorb not more than one-half the water it has this year.

On secs. 21, 28, and 33, T. 31 S., R. 28 E., and sec. 4, T. 32 S., R. 28 E., 12 miles from Bakersfield, in the vicinity of Kern Lake, 800 acres

of wheat, corn, and alfalfa were irrigated once, 250 acres irrigated twice, and 100 acres three times. The entire acreage required a total of 66,450,000 cubic feet of water during the season—equivalent to a depth of 1.33 feet at each irrigation. The average cost of water was 50 cents per acre for the season. The soil is a stiff, black loam, 1 to 2½ feet thick, underlain by yellow clay 2 to 4 feet thick, beneath which surface water is abundant in a stratum of sand. Moisture is also found above the clay, maintained by drainage of lands above.

On sec. 4, T. 31 S., R. 27 E., in one experiment 3¼ acres, prepared with care, leveled, and checked with proper levees, were covered in fifteen hours with an average discharge of 2⅔ second-feet, equivalent to a depth of 0.87 foot over the whole area. The land lies adjacent to Panama Slough, from which it receives moisture by percolation. The soil is a sandy loam of considerable depth. The surface water is 8 feet below the surface. The land had been irrigated four or five years.

At Livermore Ranch (Greenfields), secs. 18, 20, 29, 30, 31, 32, T. 31 S., R. 29 E., and sec. 5, T. 32 S., R. 29 E., the average number of waterings required is 1½—one general irrigation and a second irrigation on the drier spots. The average cost per acre for labor of irrigation is 12 to 15 cents. The average cost for the season for labor and water is $1.50 per acre. The water was shut off from March 17 till May 15, causing the failure of 300 acres of barley and 600 acres of wheat that had been sown. No data could be obtained as to the quantity of water used per acre. The ranch being at the terminus of the main canal and the central branch, the supply fluctuates according to the demands from the lands above.

Mr. Schuyler says: "These examples are all taken from lands requiring comparatively little water, as they are all subject to percolation from numerous sources. Most of the lands referred to are irrigated from the Kern Island Canal. This being the only canal in the county from which water is sold by measurement, the data afforded regarding the cost of irrigation and the quantity consumed are more definite and reliable than any that could be obtained elsewhere."

A few other examples may be given as approximately correct to illustrate the thirstiness of other classes of soils.

On Bellevue Ranch, T. 30 S., R. 27 E., no exact data as to volume of water used could be obtained. The average number of irrigations required for cereals is two to three, one being sometimes sufficient in seasons of favorable rainfall. For alfalfa three or four irrigations are generally needed; for corn two are sufficient. The soil is sandy, with streaks of heavy loam marking the course of old sloughs.

On McClung Ranch, secs. 3, 4, and 5, T. 30 S., R. 26 E., and sec. 1 in township adjoining, the first year of irrigation (1874) a ditch, described as "12 feet wide on bottom, 2 feet deep, with a good average flow," was discharged for seven months upon 100 acres before the land was saturated. If this be true, such a ditch, with side slopes 1 to 1 and

grade of, say, 2 feet per mile, would have discharged enough water in that time to cover the land 166 feet deep. The water was, of course, not confined to the immediate neighborhood of the tract upon which it was discharged, but spread for miles in underground channels, filling up the loose porous soil to a depth of several feet. The average head of water which one man can conveniently handle in irrigating on the McClung Ranch is what will pass through a gate 4 feet wide with a depth of overfall of about 1 foot, equivalent to about 13 second-feet, and with this from 1 to 6 acres per day (of twelve hours) can be irrigated. This discharge is sufficient to cover the land from 2 to 13 feet deep. The land has been irrigated from three to four years, and absorbs a trifle less each year; but if irrigation be suspended for one season the surface moisture drains away, and the following year much more would be required than would have sufficed the previous year. This is the case, to a greater or less extent, in all parts of the valley of Kern River. On the lands cited in this example one thorough soaking is sufficient to produce a crop of cereals, with enough rainfall to sprout the grain. With no rain two irrigations are required—one to prepare the land, the other to mature the crop. Alfalfa requires three to four waterings through the season to maintain a vigorous growth. The soil is a coarse sand and sandy loam of great depth.

In sec. 13, T. 29 S., R. 27 E., on a strip of bottom land between the McCord Canal and Calloway Slough, 80 acres of alfalfa have been irrigated in four days and nights with a discharge of about 6 second-feet, sufficient to have covered the ground to a depth of 0.6 foot. The land had been irrigated for two or three years. The soil is an alluvial loam having an elevation of but 5 or 6 feet above the river, and receiving constant moisture from below by percolation. The crop was irrigated twice during the season prior to August 1.

On sec. 14, T. 29 S., R. 27 E., with a discharge equal to about 2 second-feet 2 acres of corn can be covered in a day of twelve hours, equivalent to a depth of about 2 feet over the whole area. This example was given as the fourth and last irrigation of the tract in the season, the land having been wet once before seeding and three times after. The land had been irrigated several years. The soil is a brown sandy loam 1 to 6 feet deep, underlain by hardpan not wholly impervious.

On sec. 8, T. 29 S., R. 27 E., alfalfa is said to require irrigation twice a month. Wheat is irrigated once before and twice after planting. Corn requires five irrigations, the first of which is given before seeding, in May, the last in the latter part of July. The soil is a sandy loam 2 feet deep, underlain by 2 feet of yellow hardpan. No data as to quantity of water required at each irrigation were obtained.

On sec. 27, T. 28 S., R. 26 E., the first irrigation was in 1879. Wheat required three or four irrigations, one prior to sowing. The land was irrigated by the check system, by which two men could water 160 acres in four days, at a cost of about 10 cents per acre per irrigation for

labor. The soil is similar in character to that cited in the foregoing example.

At Poso Ranch, sec. 9, T. 27 S., R. 25 E., a test was attempted to ascertain, if possible, the quantity of water absorbed by the desert lands on the plains north of Kern River, now supplied by the Calloway Canal. A check containing 3¾ acres was prepared and water was admitted in as great quantity as was expedient for the safety of the newly built banks about the gates. An hourly record of the head was kept, the discharge being from 4 to 9 second-feet. Eleven hours were required to fill the check sufficiently to barely cover the highest ground, when the water was shut off. Next morning all the water had soaked away. The quantity discharged was sufficient to have covered the whole area to a depth of 1.75 feet. A portion of the area doubtless absorbed five times as much as the higher spots, as the percolation seemed to be entirely downward, and not in a lateral direction. Three weeks later the check was filled in four hours and twelve minutes, with an average discharge of 13.35 second-feet, the ground being covered to an average depth of 1.25 feet. Some time between these two experiments the land was flooded by the breaking of a check above. The total quantity absorbed by the three waterings was probably not less than 4 to 5 feet. The soil is a brown sandy loam, of unknown depth, but probably greater than 20 feet to hardpan.

All of the above examples, illustrating at once the practice of irrigation and the amount of water required, are the result of inquiries and experiments made in 1879. To these the following can now be added.

On sec. 30, T. 30 S., R. 28 E., in August, 1881, water from the Kern Island Canal was used for five days to the extent of 3.63 second-feet for the irrigation of 30 acres of corn. The amount of water was equivalent to 1.21 feet over the entire area. The water was applied by the furrow system of irrigation. The soil is very variable, generally light and loamy. Its character ranges from pure sand to black adobe. Soil water is at a depth of 8 or 9 feet.

On the same section as the last, 60 to 70 acres of wheat were irrigated by flooding in checks lying between contour lines. The surface of the ground is smooth but not level. Water was used for eleven days in December, January, and February, at the rate of 3.61 second-feet, equivalent to a depth of 1.21 feet over the whole surface. It was again used for eight days in March, at the rate of 3.26 second-feet, equivalent to a depth of 0.97 feet over the entire surface. The ground received another irrigation between April 1 to 5, four days in all; water was used at the rate of 5.20 second-feet, and the equivalent average depth of water over the entire surface was 1.37 feet. The whole amount of water consumed in the irrigation of the wheat was therefore equivalent to an average depth of 4.18 feet of water over all. Alfalfa was irrigated on the same section to the extent of 50 to 60 acres. The water used for it prior to the end of May, 1882, was 5.20 second-feet for fourteen days in

March, and 7.36 second-feet for fifteen days in May. The amount of water which the alfalfa field received in these two irrigations was equivalent to a depth of 6.61 feet. It was proposed to give it, and it probably received, two more irrigations subsequent to the two here noted.

Sec. 31, T. 30 S., R. 28 E., has a loamy soil which does not crack or bake in drying, contains a small excess of alkali, and ranges in texture from sand to black adobe. In 1881 wheat to the extent of 125 acres was irrigated by flooding in checks. The surface of the ground is smooth but not level. The ground was wet before plowing in January. The amount of water it received at that time was equivalent to a layer 5.01 feet thick. It received a subsequent irrigation equivalent to a depth of 0.69 foot of water. The total average depth of water delivered to the land was therefore 5.70 feet.

On the same section, in 1882, a wheat field of 350 acres was supplied with water for sixteen days in the first part of January. Water was used at the rate of 3.26 second-feet, equivalent to an average depth of 0.30 foot. It received water again, at the rate of 7.41 second-feet, from April 1 for seventeen days, equivalent to 0.76 foot in depth over the whole area. For fourteen days, from April 25 to May 8, it again received water, at the rate of 8.60 second-feet, equivalent to a depth of 0.66 foot over the whole area. The aggregate average depth of water received by this whole tract in 1882 was therefore 1.72 feet.

On sec. 6, T. 31 S., R. 28 E., having soil of the same character as that described above for sec. 31, 120 acres of corn land were irrigated, from April 18 to 24, in 1882. This irrigation was preparatory to the planting, and was equivalent to a depth of 0.78 foot over the whole surface of the land. The corn received one more irrigation.

On sec. 32, T. 30 S., R. 28 E., whose soil is mostly a sandy loam, but ranges from pure sand to a dark vegetable loam, 130 acres of wheat were irrigated in March and April, 1881. The head of water used was 9.91 second-feet. The depth to which it would have covered the ground averaged 2.34 feet. Ground water is at about 17 feet below the surface.

On the same section, in May, June, and July, 1881, 80 acres of corn received water to the extent of an average depth over all of 6.35 feet. The head of water was 9.91 second-feet. On the same section a 6-acre orchard was irrigated in August and September, 1881, and received water enough to cover the 6 acres 4.53 feet deep. The water used was 4.56 second-feet. On the same section, in March, 1882, an old alfalfa field of 100 acres was irrigated and absorbed water equivalent to a depth of 2.52 feet. The head of water used was 12.10 second-feet. On the same section, in March, 1882, newly sown alfalfa was irrigated; its area was 120 acres. It received water at the rate of 12.10 second-feet. The total amount of water it received was equivalent to a depth of 2.52 feet over the whole area. It was again irrigated in May, receiving 8.60

second-feet for eight days, or sufficient water to cover it 0.98 foot deep. It was proposed to give the newly sown alfalfa one more irrigation in 1882.

On sec. 7, T. 31 S., R. 28 E., whose soil varies from a light sandy loam to a black sandy vegetable mold, with ground water at from 4 to 10 feet below the surface, 300 acres were sown to wheat in 1882; alfalfa was sown with the wheat. The ground was not irrigated before sowing. The irrigation of this tract commenced on February 25 and was completed on April 6; water was used for forty-one days at the rate of 8.21 second-feet. The total amount consumed in irrigating the 300 acres was equivalent to a layer 2.22 feet thick over all. The wheat did not require any further irrigation. The young alfalfa was irrigated again after the wheat had been harvested.

IRRIGATION FROM POSO CREEK.

Poso Creek is a small foothill stream just northward from Kern River, which flows for several months each year. Its drainage basin has an area of about 289 square miles. The creek has not been used to any considerable extent for irrigation, because there is but little land that can be commanded with its water except at considerable expense, and because its brief irregular flow did not seem to justify works to benefit large sections. It was not, therefore, until the irrigation-district law went into effect that a combination of interests led to the projection and partial execution of works of considerable magnitude. Several small private ditches were in use before the organization of the Poso irrigation district, but no complete list of these is available. One of them is the Purcell Ditch, which takes water from the south side of Poso Creek, about 8 miles above Poso. The ditch was made 12 feet wide and 2 feet deep, and was in use in 1885 for the irrigation of about 400 acres of alfalfa, immediately below the head of the ditch and adjacent to the creek. Another ditch, on the south side of the creek, is the Creasey Ditch, constructed in 1885 for the irrigation of 300 acres of land about 4 miles above Poso. The head of the ditch is about 2 miles below the head of the Purcell Ditch. It was made 16 feet wide on the bottom. The Rhymes and Hughes ditches are small ones, somewhere in the foothill section drained by the creek, concerning which nothing definite is known except that they were in use for many years.

POSO IRRIGATION DISTRICT.

This district was organized in 1888. Its bond issue is $500,000. It has an area of about 40,000 acres, located to the north of Poso Creek, at the western base of the Sierra Nevada foothills, in Kern County. The contemplated works for the irrigation of the district are far advanced, though not yet completed. Much work on them was done by day's labor before it was decided to be advantageous to let contracts.

Water for the district lands is to be obtained from a system of reservoirs in the drainage basin of Poso Creek, which are to supplement the creek's natural flow. The first reservoir, now constructed, is formed by means of an earthwork dam to be raised to a maximum height of 70 feet, but now only half finished. Its capacity when completed will be about 7,000 acre-feet. From it water flows in the channel of Poso Creek about 7 or 8 miles to a point where it is diverted into a flume by means of a granite dam, whose greatest height is about 16 feet. The flume shown in Pl. XIV, *A* and *B*, is about 3 miles long and delivers its water into an apparently well-constructed hillside ditch which has a length of about 30 miles before reaching the district. Two other flumes are in use on the canal line to carry the water over deep ravines. The flumes have a width of 8 feet and are planned to carry water 4 feet deep. Water was sent through the canal for the first time this season, but only for the purpose of testing the work. This upper district canal is supplemented by a lower canal which leaves the creek about 10 miles above Famosa and commands the western portion of the district. This lower canal is in service, but irrigation is extending very slowly.

IRRIGATION FROM DEER CREEK.

Deer Creek is a small stream draining about 110 square miles of Sierra Nevada foothill lands lying southward from the Tule River basin. It flows into San Joaquin Valley during several months of the year; rarely, however, as late as July. Its water ordinarily sinks within 10 or 12 miles of the foothills, but occasional freshets have sent it as far as Tulare Lake. The summer flow of the creek, which is very small, does not reach the San Joaquin Valley lands.

Winfield Ditch.—This is a small ditch on the south side of Deer Creek, having its head about 4 miles above the point where the creek breaks out upon the main valley plain. It was constructed in 1858, is between 3 and 4 miles long and 3 to 4 feet wide, and supplies water to several hundred acres of creek bottoms. It has been in use continuously since its construction. The entire low-water flow of the creek is taken into the ditch.

Carothers Ditch.—The head of this ditch is on the north side of Deer Creek, about a mile above the point where the creek reaches the border of San Joaquin Valley. It was constructed in 1885, but takes its name from an older ditch (constructed in 1868) which had for many years been out of service. It has a westerly course, and is about 5 miles long and 4 feet wide on the bottom.

Deer Creek Consolidated Ditch (*Sausalito Ditch*).—This is the principal irrigation work on Deer Creek. The head of the ditch is on the south side of Deer Creek, about 12 miles in a direct line above Belleville and about 3 miles below the head of Carothers Ditch. The ditch is carried

A HEAD FLUME, POSO IRRIGATION DISTRICT.

B. HEAD FLUME, POSO IRRIGATION DISTRICT.

along the south side of Deer Creek, close to the creek channel, for a distance of nearly 8 miles; thence its course is diagonally across the creek bed to its north side. From this point the course of the ditch is westerly and southwesterly, in a number of branches, which deliver water to lands lying to the east and northeast of Belleville. The crossing of the sandy bed of Deer Creek is effected between embankments of sand, which are sure of destruction during freshets, but which are quickly restored. The lower portion of this ditch system was constructed in 1875 and 1876. Two sets of farmers commenced operations independently, but soon found it advantageous to unite their interests and construct a ditch in common. It was soon found necessary to substitute an artificial channel on firm ground for the porous creek bed from the foothills to the head of the original ditch, and this led to the construction of the upper section of the ditch in 1878. The main ditch has somewhat irregular dimensions. Its bed width is generally about 10 feet. Its capacity has been estimated at 40 second-feet. The capacity of the lower section of the ditch, on the north side of the creek, is about 30 second-feet. The cost of this irrigation system, which furnishes water to 3,000 acres of land, was about $20,000.

When the consolidation of interests by those desiring to use water near Belleville was effected, it was determined to establish water rights that should become appurtenant to specified tracts of land. This plan could not be adhered to, however, owing to insufficiency of the water supply from the creek, which made it impossible to deliver water to many of the tracts westward from Belleville for which water was wanted. It was found necessary to confine the delivery of water to consumers near and above (east of) Belleville, and these have become the stockholders in the company which owns and manages the ditch.

During the irrigating season (generally November to the end of June) a ditch superintendent is in charge of water distribution. Water is delivered to the several branches in proportion to the number of shares of stock for which each is to receive water. As soon as the water becomes insufficient to meet the demands of irrigators the ordinary system of using it in rotation is adopted. Eight hours is usually fixed as the time of a run per share. No water is sold, and all expenses are assessed upon the stockholders. Management and repairs cost about $1,000 per annum. About one-third of the area irrigated is alfalfa; the rest is orchard, vineyard, summer crops, and some grain. Irrigation is accomplished by flooding in small rectangular checks. The preparation of the ground to receive water was inexpensive, its original surface having been very smooth. The soil is a sandy loam. At about 3 feet below the surface is a stratum sufficiently hard to be called hardpan. As usual in irrigated districts on the plains, irrigation has produced a permanent effect upon the elevation of ground water. This was originally found at a depth of 17 feet below the surface; it is now at 9 to 12 feet.

TULE RIVER.

HYDROGRAPHY.

Tule River enters San Joaquin Valley at Porterville, with a drainage area above that point of 437 square miles. The river has a perennial flow throughout its mountain and foothill portions, but not at points below Porterville, near where the last remnant of its water during very low stages sinks into its sandy bed. During the months of May and June the flow of the river, as estimated for the six years, 1878 to 1884, was over 1,000 second-feet. Its mean flow for that entire period was about 450 second-feet. From November to January the mean flow was 130 second-feet. It was 636 second-feet from February to April, 941 second-feet from May to July, and 139 second-feet from August to October.[1]

Below Porterville this water flows in several channels, one of which, Porter Slough, has its head on the north side of Tule River, about 3 miles above Porterville. The water not in this slough remains in the main channel for about 10 miles, then separates into a network of channels having a general westerly course, and is finally delivered into Tulare Lake. The main stream crosses the Southern Pacific Railroad about 2½ miles north of Tipton. Water rarely flows in this part of the river more than four months of the year.

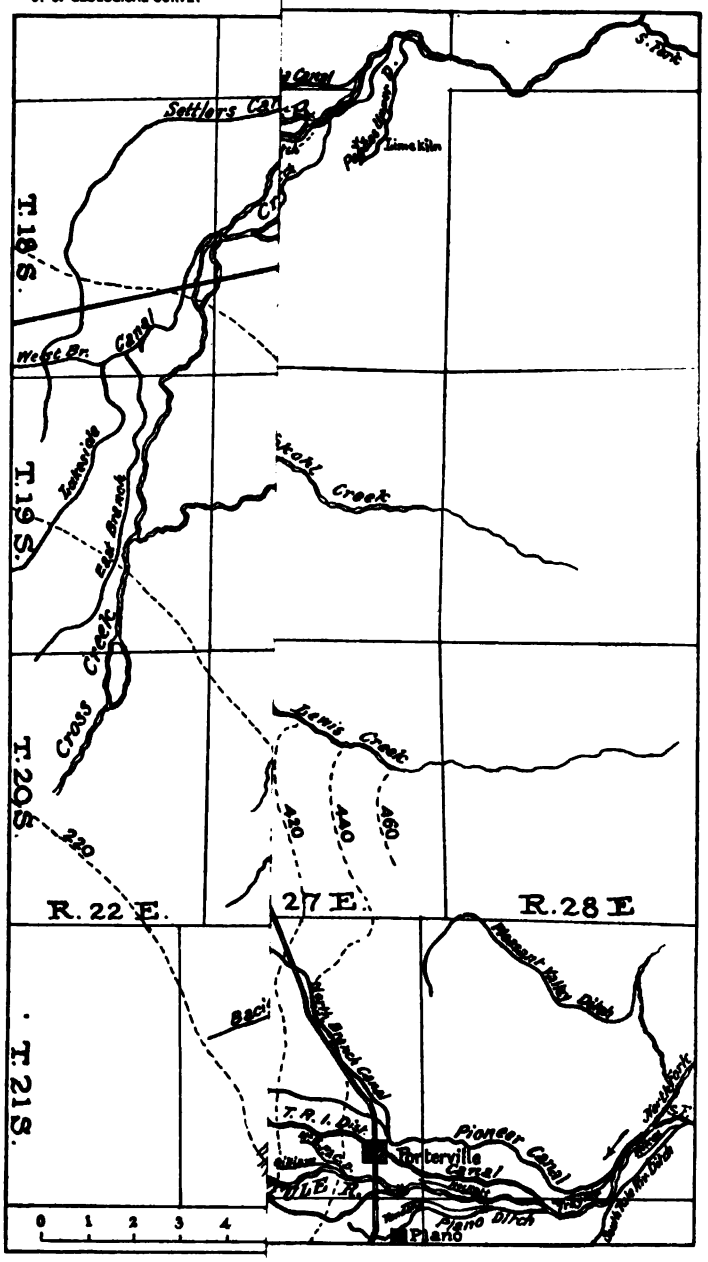
The Tule River channels are barely of sufficient capacity to pass ordinary freshets. This is particularly noticeable westward from Woodville on all the many channels into which the river is subdivided. The resulting bank-land inundations are of considerable extent and are an important supplement to artificial irrigation. The ready overbank escape of the freshet waters of the river and the very smooth surface of the delta lands greatly facilitate the diversion of water into ditches and canals, which have become very numerous. Many of these are, however, mere cuts into the bank, into which water flows when the river is high and which become dry soon after the river recedes from its highest stage.

Where there are so many small, relatively unimportant diversions as from the several channels of Tule River, a minute description of each work will not be attempted, and in many cases a mere mention of name, general position, and time of first use must suffice.

CANALS AND DITCHES.

South Tule River Ditch.—This (sometimes called Campbell Ditch) is the uppermost ditch on the south side of Tule River, though by no means the first in time of construction. The diversion of water from the river is made at the head of an older ditch, known as the Wilcox, at a point about 8 miles above Porterville. The ditch skirts the base

[1] California Physical Data and Statistics, Wm. Ham. Hall, State Engineer, pp. 458 and 476.


T.18 S.
T.19 S.
T.20 S.
T.21 S.
R. 22 E.
27 E.
R.28 E
Settlers Canal
Lime kiln
West Br. Canal
Zaterville
East Branch
Cross Creek
Lewis Creek
420
440
460
220
Pleasant Valley Ditch
West Branch Canal
T.R.I. Ditch
Pioneer Canal
Yuba River
Zaterville Canal
Plano Ditch
Plano
0 1 2 3 4

of the hills, commanding a narrow strip of valley land which lies between the hills and the river. It is about 6 feet wide on the bottom, and has irrigated but a few acres. Its construction was commenced in 1879.

Wilcox Ditch.—The diversion of water into the Wilcox and South Tule River ditches is accomplished by means of an inexpensive wing dam of cobbles and brushwork. One channel in common is utilized for the water of both ditches for about a quarter of a mile. The Wilcox Ditch lies between the South Tule River Ditch and the river. It was constructed about 1855 for the irrigation of a small tract of land 2 miles below its head. The ditch is about 3 feet wide on the bottom.

Plano Ditch.—For the irrigation of lands in the vicinity of Plano, a small settlement on the south side of Tule River, directly opposite Porterville, a small ditch was constructed in 1863. It takes water from the south side of the river, about 3 miles in a direct line from Plano. It gradually withdraws from the river, crossing the river bottoms to the base of the hills, and skirts the base of "Sugarloaf" just to the east of Plano. Thence its course is southwesterly through Plano to a termination about 1 mile west of the village. The dimensions of the ditch are irregular; its capacity is about 16 second-feet. It supplies water to about 400 acres of orchard, alfalfa, and vegetables.

Vandalia Ditch.—This is another small ditch on the south side of Tule River. It takes water from the river a mile above Plano, has a capacity of about 3 second-feet, and irrigates about 100 acres. It was constructed in 1861.

Rose Ditch.—This is another of the small private ditches near Plano. Its head is several hundred yards below the head of the Vandalia Ditch. It was constructed in 1862. The land it irrigates was before that time supplied with water from a ditch known as the Somers Ditch, but the freshets of 1861–62 cut the irrigated district in two by the formation of a new channel for the river, and the Rose Ditch was built to supply water to a few acres of the original irrigated district left on the south side. It irrigates 10 to 20 acres.

Mitchell, Springer & Rose Ditch.—The head of this ditch was a short distance above the bridge on the road southward from Porterville. It was less than a mile long and about 4 feet wide on the bottom. The point at which water was taken from the river was frequently changed, and various tracts of land were irrigated with its water. It was one of the old-time ditches which now seems to have fallen into disuse. The extent of irrigation from it a few years ago was less than 20 acres.

South Side Tule River Canal.—This canal, which was for many years referred to as the "Big Ditch," and is also known as the "Poplar Canal," was constructed in 1875 by an organization of farmers whose lands were located on the main San Joaquin Valley plain, south of Tule River. The head of the canal is just above the bridge southward from Porterville. The canal regulator has been placed about a quarter

mile below the bridge. The ditch has a bed width of 20 feet, and is intended to carry water 2 to 3 feet deep. The course of the canal is westerly. It is about 11 miles long. In seasons of ordinary rainfall there is no trouble in keeping the canal well supplied with water during the spring months. At other times, and often when water is most needed, the supply is scant. The flow of the main canal is usually apportioned to one or more of the distributaries, or district ditches, as they are called, and the entire flow of each of these is used in turn by the irrigators. The length of time that an irrigator may use the water is determined by the number of shares of stock held by him.

The use of the canal has been interfered with considerably by litigation. Riparian land owners have been successful in throwing legal obstacles into the way of water diversion for this canal, and court decisions against canal interests have been enforced to some extent. The area irrigated has, therefore, remained small—probably less than 1,000 acres. The cost of the canal was about $20,000, but under good management would have been less. Check weirs were placed in the

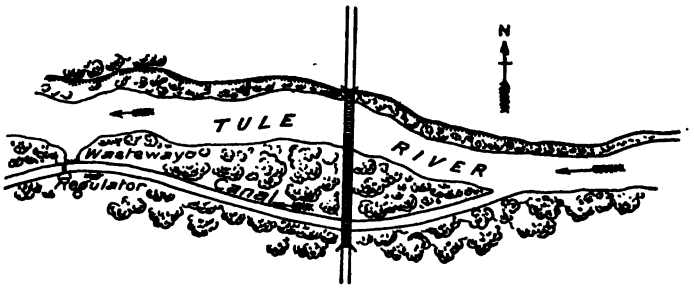


FIG. 14.—South Side Tule River Canal.

canal every half mile, but did not serve long. They were soon washed out of place. Their purpose was to prevent excessive erosion (the fall in the direction of the canal being about 15 feet per mile) and to facilitate diversion into branch ditches. After the first set of these structures was gone the expense of placing a weir in the main canal at the head of a distributary was thrown upon the owners of the latter, but the canal management reserved the right to approve the design and to supervise its construction. The original check weirs were of the flashboard type. The bays had a width of 4 feet. The timbers supporting the flashboards were inclined. The principal defect seems to have been the placing of the floor of the structure at, and not below, the grade height of canal bottom.

Fine Ditch.—The head of the Fine Ditch is about 3 miles below the head of the South Side Canal. It commands a district intermediate between Tule River and the lands irrigated with water from the South Side Canal. The ditch was built and is owned in common by a number of farmers, who apportion its water among themselves. It is about 7 miles long.

A. REGULATOR AND WASTE WAY OF SOUTH SIDE TULE RIVER CANAL.

B. REGULATOR OF PIONEER CANAL, LOOKING UPSTREAM.

Callison Slough.—Callison Slough (Woods Central Ditch) is a high-water escapeway from the south side of Tule River, about 5 miles due west from Porterville. It was probably one of the many new channels formed by the freshets of 1861–62. Water enters the head of this slough under control of a regulator at the high stages of the river, and at lower stages the flow is increased by means of a temporary wing dam of sand, which is extended farther and farther upstream as the river falls. The flow of the slough has been under control for irrigation since 1878, in which year a company was organized for this purpose, under the name of the Woods Central Irrigating Ditch Company. The head gate was made 18 feet wide. About $1,560 was expended in converting the slough into a serviceable ditch. Several small distributing ditches have been constructed from the slough to the lands of irrigators, and about 1,000 acres represent the extent of annual actual wetting.

When the Tipton irrigation district was organized, in 1891, arrangements were made by its directors for the use of Callison Slough in com-

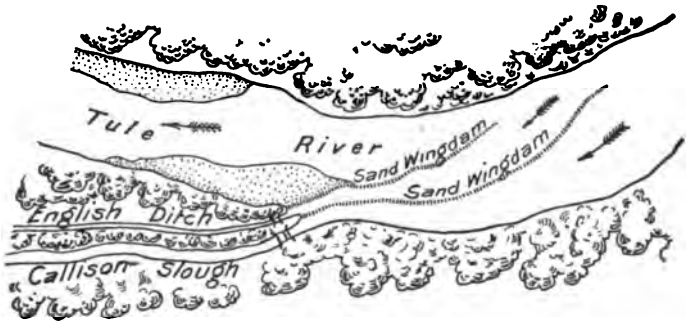


FIG. 15.—Head of Callison Slough and English Ditch.

mon with the Woods Central Irrigating Ditch Company. A new regulator was soon afterwards put into the head of the slough. It was made 30 feet wide, it being understood that 10 feet of its width was to serve the original users of slough water, and the other 20 feet the irrigation district. The district canal is out of service at the present time.

Old English Ditch.—The head of this ditch is immediately below the head of Callison Slough, and its water is used on several small farms between Callison Slough and the river. The ditch was constructed about 1869. It is about 8 feet wide on the bottom, 2 miles long, and annually irrigates between 100 and 200 acres. Whenever it is desirable to use water after the high stage of the river, a long temporary wing dam of sand is constructed at its head, just below, and almost parallel with, that at the head of Callison Slough.

Stockton Ditch.—This ditch takes its name from a small private ditch which was in use for a few years preceding 1871. It was built in 1874 by a company composed of eight farmers who desired a common source of supply. It leaves the south side of Tule River about midway

between Porterville and Woodville, and has a westerly course to the vicinity of the latter settlement. The ditch is about 6 miles long, and is 15 feet wide at its head. Water is ordinarily available for it from February to June. No restriction is placed upon the locality where each stockholder may use his water. The water is delivered in turn to each person entitled to its use, the time of a "run" per share of stock being fixed annually by the directors, usually at forty-eight or twenty-four hours per share. The lands irrigated by this ditch have in part been included in the Tule River irrigation district, and are to become dependent upon its works for their water supply.

Ball & Harris Ditch.—About one-half mile below the head of Stockton Ditch a small ditch, irrigating several hundred acres of land, leaves the river. It is known as the Ball & Harris Ditch (or the Markham, or Pierce & Markham, or Pierce, Markham & Booth Ditch). It was built about 1871, and is reported to have been in continuous use after 1874. The ditch is only 3 to 5 feet wide on the bottom. Its regulator has a width of 6 feet. This is one of the ditches whose rights have been merged with those of the Tule River Irrigation Ditch Company.

Empire Ditch.—The head of this ditch (also called Pheil & Otto, Stover, or Lower Pioneer Ditch) is on the south side of Tule River, 3 miles east of Woodville, at a point known as the Forks of Tule River. Its course is westerly; it is 3 miles long and irrigates several hundred acres of land in the immediate vicinity of Woodville. Its width is 2 to 3 feet on the bottom, and its estimated capacity is about 5 second-feet. The lands served by this ditch are in part in the Tule River irrigation district.

Woodville Ditch.—This ditch has its intake on the south side of the river about 1½ miles northeast of Woodville. Its course is westerly; its length is about 7 miles, and its width in the upper sections about 10 feet on the bottom. The regulator has a width of 12 feet. The ditch was constructed in the years 1883 to 1885. It is one of the few ditches constructed and managed on the principle of proportional assessment of stockholders to meet those expenses only which are incurred on the ditch above the point where water is delivered to each irrigator. This is another of the small ditches whose rights have been merged with the Tule River Irrigation Ditch Company.

Tipton Ditch.—This ditch (also called Mitchell Ditch) was constructed for the irrigation of lands near Tipton. Its builders agreed to contribute to the cost of construction and maintenance of so much of the main ditch as was above the upper limits of their lands in proportion to their respective interests in the canal water. The construction of the ditch commenced in 1881, but it was not completed for several years. The head of this ditch is on the south side of Tule River, about 3½ miles northeast of Tipton. The ditch has a southwesterly course, is 6 to 7 miles long, about 20 feet wide near its head, and is planned to deliver a relatively large amount of water to the area dependent upon

it during the short period (about February 1 to June 15) when water is ordinarily available.

Janes Ditch.—This is a very small private ditch, the head of which is about a quarter mile below the head of Tipton Ditch. It follows the river bank, crossing Lone Oak Slough and South Tule River to a small tract of land irrigated with its water.

Lone Oak Slough.—This is a small high-water channel breaking out of the south side of Tule River due north from Tipton, about a half mile above the railroad crossing. It has a southwesterly course, and supplies water to several independent small distributaries known as the Hively, the Creech, and the Rogers Lower ditches. The flow of water in the slough is controlled by a regulator, put in about 1891.

Hively Ditch.—This is a small private ditch, about a mile long, receiving water from Lone Oak Slough just to the west of the railroad crossing.

Creech Ditch.—This is another small private ditch, about a mile long, leading from the south side of Lone Oak Slough.

Rogers Lower Ditch.—This ditch also receives water from Lone Oak Slough. It is a mile below the Creech Ditch, and is about 2 miles long.

The combined irrigation from Lone Oak Slough ditches probably does not exceed 200 acres.

Fancher Ditch.—Another of the Tule River ditches, owned in common by four or five irrigators, is the Fancher Ditch, which for several years prior to 1884 is reported to have received its water from the river at the point where Callison Slough unites with South Tule River. A weir was constructed in the river channel and the diversion was made from the slough channel. About 1884 it was found necessary to extend the ditch upstream about half a mile to a new head, where for some time water was admitted without control. The ditch has a southwesterly course, is about 2 miles long and 12 feet wide, and usually irrigates several hundred acres.

Finney Ditch.—On the north side of South Tule River, near the last-mentioned diversion, is a small private ditch, known as the Finney or Berry Ditch. Its head is a quarter of a mile below the head of Fancher Ditch. Water is there diverted into a small natural depression, in which it flows about half a mile to points where it is used by several irrigators. This ditch came into use in 1884.

Swall Ditch.—Another small private ditch, on the north side of South Tule River, is the Swall Ditch. Its use dates back to 1875. Its head is 2½ miles below the head of the river channel called South Tule River. It is about 2 miles long, and has a westerly course.

Gully Ditch.—This ditch receives water from the south side of the main channel of Tule River, 1½ miles below the head of South Tule River. It has a southwesterly course, is about 2½ miles long, and, in common with the Swall Ditch, supplies water to several hundred acres. It was constructed in 1875.

Swall & Wessling Ditch.—This is a small ditch on the south side of the main channel of Tule River, about a mile long, which connects this channel with a small natural water course. Its head is 3½ miles below the head of South Tule River. It has been in use since about 1884.

Great American Ditch.—Before the Tule River Indian Reservation, above Porterville, was thrown open to settlement the construction of a small hillside ditch for the irrigation of lands intermediate between the north-side hills and the river had been commenced. This ditch had its head on the west side of North Fork about 8 or 9 miles above Porterville, and was intended solely for the use of the Indians. This work was subsequently to have been completed by a corporation which seems to have been organized principally for speculative purposes. There is but little left of the enterprise except the name.

Pleasant Valley Ditch.—This is a diversion from the west side of North Fork of Tule River, about 2½ miles above its junction with Middle

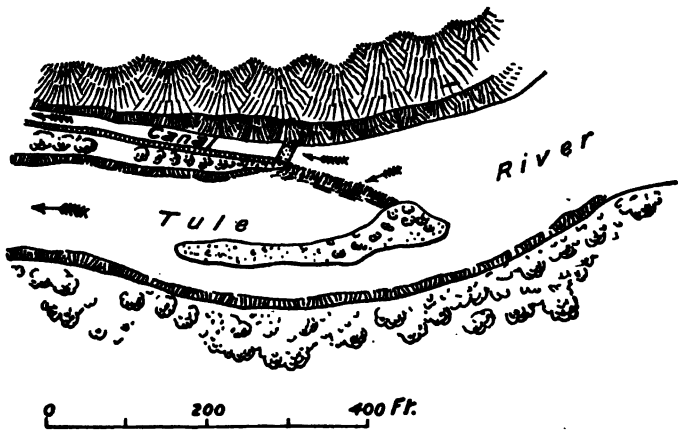


FIG. 16.—Head of Pioneer Canal.

Fork. The ditch has a southerly course for over 5 miles, thence a northwesterly course for 5 miles, and thence a southerly course for over 2 miles. It commands Pleasant Valley lands. Its bed width is about 6 feet for several miles, thence 4 feet. The ditch was constructed in 1889 by the Pleasant Valley Ditch Company, organized as a corporation the previous year by farmers requiring water for stock and irrigation purposes.

Pioneer Canal—This canal, controlled by the Tule River Pioneer Water Ditch Company, is the most important of the several irrigation works receiving water from Tule River. It was constructed and first came into use about 1867. Its head was then located three-quarters of a mile below the junction of North and South forks of Tule River. The freshets of 1877–78 destroyed the upper section of the canal and at the same time cut a high-water channel near the base of the hills at the northern border of the bottom lands. This new channel was at once utilized for

the canal water. A regulator was put in its head and has been maintained. The canal proper terminates at the flour mill at Porterville, to which it supplies power. Its course is along the base of the hills on the north side, and generally half a mile to 2 miles from the river. The bottom lands thus commanded above Porterville are very productive. The canal has a length of about 7 to 8 miles. Its fall is somewhat irregular, generally 6 to 7 feet to the mile. Its bed width is 8 to 12 feet, and the depth of water carried 2 to 3 feet. Its regulator is of the box or culvert type. A loose-rock fill on top of the structure gives it weight to prevent its being undermined. Three vertically sliding gates control the inflow of water. The width of the regulator between side walls is 18 feet. The capacity claimed for the Pioneer Canal is 72 second-feet.

Before a reorganization of the canal company was effected, several years ago, the canal water was delivered to stockholders in proportion to the amount of stock owned by each. Stockholders were permitted to take their water at any convenient point through a suitable outlet gate, constructed and maintained by the user of the water taken. No water was sold by the canal company, and all expenses of management and repairs were assessed to the stockholders. The result of this system of operation was the union of interests by groups of irrigators, who then made a common diversion of water from the main ditch and built distributing ditches, which are managed much the same as independent ditches.

The most notable branch of this character was the Farmers Ditch. It received water from the Pioneer Canal at the mill, and, passing to the east and north of Porterville, had a course a little north of west, skirting the southern border of Old Tule River Swamp. Its length was about 12 miles. It was owned by an organization formed in 1875, ownership being represented in 12 shares. Each share of stock entitled its holder to a proportional interest in the canal down to a point where he diverted or intended to divert his water from the main canal. The company did not sell any water. Water was used from the canal in rotation, the duration of a run per share of water being mutually agreed upon.

The cost of construction was apportioned to each member in proportion to his interest in the canal. Each member bore a proportional part of all expenses incurred along the canal above the point at which he was to receive his water, and did not contribute toward the construction of the canal below that point. Expenses of maintenance and repairs were apportioned on the same basis to those actually using water. As the canal had a total length of 12 miles, and some of its water was used within 3 or 4 miles of its head, these expenses were about four times as great for the most distant irrigator as for the one nearest the head of the canal.

Farmers Ditch in its upper sections was also known as the Old State

Ditch, being one, or on the line of one, of the ditches that was intended to divert the flow of flood waters from the Old Tule River swamp lands, and which had been constructed with money from the State swamp-land fund. This ditch, in somewhat altered alignment, together with the North Branch of Pioneer Canal (which might also be called the North Side State Ditch), has become one of the principal distributaries of the reorganized Pioneer Canal Company.

Water is still delivered to stockholders in proportion to stock owned, but without actual measurement. A change is to be made at once, according to which water is to be sold to stockholders on the basis of 1 miner's inch per share of stock. The canal capacity, 50 second-feet, is equivalent to 3,600 miner's inches under 4-inch pressure, and there are 3,600 shares of stock in the corporation. The price to be charged for water is to be fixed at 5 cents per 24-hour miner's inch.

The area of citrus fruits dependent upon this canal for water has within the last few years rapidly grown to 1,000 acres. About 900 acres of other orchards are also irrigated by this canal. The orchard lands for the most part lie to the north and east of Porterville.

The wetting of orchard land is generally accomplished by allowing small streams of water to flow in a number of furrows between rows of trees, usually four, and to harrow the surface as soon after the application of water as possible.

On the lower section of the Farmers branch of the canal alfalfa and grain are irrigated in rectangular checks. Land there is smooth surfaced and comparatively level, consequently the cost of preparation for irrigation is small. It is said to have been as low as 50 cents per acre for ditching and checking.

The value of water stock at the present time is said to range from $200 to $300 for stock entitling to water above the Porterville Mill, and $50 to $100 for stock entitling to water below the mill. This difference in price is due to the fact that most of the flow of the canal must be delivered at the mill for power purposes, and that water for diversion from the canal by irrigators above the mill is therefore limited.

Traylor Ditch.—This is a small private ditch having its head on the north side of Tule River half a mile below the head of the Pioneer Canal. It has a course about midway between the larger ditch and the river, is about 2 miles long, and irrigates a few acres of river bottom land.

Porter Slough.—Porter Slough breaks through the north bank of Tule River about 4 miles above Porterville. It was made the principal channel of Tule River by the freshets of 1861–62, but within a few years contentions arose as to the apportionment of water to this channel and to that which afterwards became the main channel of the river. Obstructions placed in the head of Porter Slough were repeatedly removed by settlers along the slough. It is claimed that such obstructions, in part at least, caused the rapid enlargement of the other

channel of the river by the freshets of 1867–68, and that ever since that time some work at the head of Porter Slough is annually necessary to put water into it at ordinary stages of the river.

Since the construction of the works for the irrigation of lands in the Tule River irrigation district, water is turned into the head of Porter Slough through an artificial channel or cut 700 feet long, in the head of which a regulator is maintained. This regulator has a total width of 36 feet, divided into nine spaces, of which seven are separated from the other two by a longitudinal partition. The water passing through the larger portion of the gate is for the irrigation district, the rest is for the Hubbs & Miner Ditch, which formerly received its water through an independent head some miles below Porterville. The actual flooding of lands with water from the slough before its use by the Tule River irrigation district was not very extensive, but the presence of water in the channel accomplished much wetting of adjacent agricultural land.

Hockett Ditch.—This is one of the small ditches which was constructed immediately after the freshets of 1861–62 to replace Somers Ditch, which was destroyed by the high waters. Its head is on the north side of Tule River, about 1½ miles below the head of Porter Slough. It supplies water for several hundred acres of land between Porter Slough and the main channel of the river southward from Porterville. The Somers Ditch, whose water rights are claimed for the Hockett Ditch, is reported to have been constructed in 1858, and it is probable that some of its original owners had attempted to make diversions of water as early as 1854.

Wallace Ditch.—The head of the Wallace Ditch is immediately below that of the Vandalia Ditch. Although the diversion of water for this ditch is made on the south side of the river, it is at once carried over to the north side in a small flume, and its use is entirely on the north side. It is a small private ditch, occupying a position between the Hockett Ditch and the river and supplying water to a few acres in the same vicinity as Hockett Ditch.

McGee, Putnam & Caldwell Ditch.—This is another small north-side ditch, having its head about 1¼ miles below the bridge south of Porterville. It commands lands between the river and Porter Slough just west of those covered by Hockett and Wallace ditches. It is said that the use of water through this ditch commenced about 1863.

Gilliam Ditch.—This ditch leaves the river about a quarter mile below the McGee, Putnam & Caldwell Ditch. It is a small private ditch which is also known as the Gillis Ditch, or the Gilliam & McGee Ditch. It was probably constructed in 1862 and commands a portion of the district originally irrigated by the Somers Ditch.

Hubbs & Miner Ditch.—This is a north-side ditch supplying water to eight or ten farmers, whose interests in the ditch are represented by shares of stock. The head of the ditch was about 2 miles below the

Porterville road bridge until, in 1893, a combination with the Tule River irrigation district was effected, according to which a common head or new inlet from the river to Porter Slough was constructed. Of the water diverted from the river, the surplus not required by the irrigation district goes to the lands dependent upon the Hubbs & Miner Ditch for water.

Fulweiler and Hunsaker ditches.—The next north-side ditch has its head about 6 miles below Porterville. It is known as the Fulweiler Ditch. Its construction was commenced by an organized association of farmers, but work was soon abandoned. One of the owners subsequently commenced operations again, and was joined in 1884 by several other farmers. The ditch was about 1½ miles in length, having a northwesterly course to a point where a junction was effected with another small ditch, known as the Hunsaker Ditch, whose head is half a mile below the head of Fulweiler Ditch. The Hunsaker Ditch had a length of about 2 miles. Its central section was used in common by the two ditches—an arrangement effected to overcome right-of-way difficulties which were encountered by the owners of the Fulweiler Ditch. The Hunsaker Ditch was constructed in 1871. About 400 acres were irrigated from the two ditches. All of the lands served by the Hunsaker Ditch and part of those served by the Fulweiler Ditch are now in the Tule River irrigation district and are dependent upon its canals for water.

Pletts Ditch.—This is a small ditch receiving water only during high stages of the river. It has been in use since 1872, but has ordinarily irrigated only about 10 acres of alfalfa and orchard land. Its head is just below the country road leading northward from Porterville.

Thomas Ditch.—Less than a quarter of a mile below the head of the Pletts Ditch, also on the north side of Tule River, is the Thomas Ditch. It is also called the Walker Ditch. It was constructed about 1871 or 1872. Like other high-water diversions from Tule River, it has had no regulator at its head. The extent of actual flooding with its water has been about 25 acres. The lands it watered are now served by the Tule River irrigation district canals.

Elrod Ditch—This is one of the same class of small ditches just enumerated. It is a reconstruction of an older ditch which was known as the Lewis & Walker, about 2 miles below the Thomas Ditch. The original ditch came into use in 1871. The lands irrigated by it are now a part of the Tule River irrigation district.

Ray & Brown Ditch.—This was an insignificant ditch on the north side of the river about 5 miles east of Bayou, which affords water for the flooding of a few acres at flood stages of the river. Like the other small ditches named, it has been absorbed by the Tule River irrigation district.

M. M. Burnett Ditch.—This is a small high-water ditch from the north side of Tule River, a mile southeast of Tagus. It is about a mile long,

has a bed width of 5 feet, and cost about $100. It was constructed in 1886.

Bond Ditch.—This is a small ditch which carries water southwesterly three-fourths of a mile from a point on the north channel of Tule River at the head of Schoolhouse Branch. It unites with Rogers Ditch for the irrigation of the same lands. This ditch was constructed in 1871.

Rogers Upper Ditch.—This is a diversion from the north side of the Stadtmüller Branch of Tule River, made in 1880. It has a northwesterly course for nearly a mile, to its junction with the Bond Ditch. The two ditches belong to the same owners.

Rogers Middle Ditch.—This is a ditch from the lower end of the Schoolhouse Branch of North Tule River. It is a short ditch 6 feet wide, having a southerly course, and drops its water into a natural channel, whence it is again taken for the irrigation of several small tracts. It was constructed in 1880.

Klein Ditch.—This ditch was practically duplicated by the Rogers Middle Ditch. The diversion was made from the same point, but in a ditch located a few feet farther east, and the same natural channel was used to convey water about a mile to its place of use. The mention of the ditch is merely historical; it went out of use about 1880.

Lamarsna Ditch.—This is another of the very small high-water ditches which abound in the Tule River country. It was constructed in 1878 or 1879, to supply water to several farms lying between the main channels of Tule River about 3 miles southeastward from Bayou. It has been in actual use very little, and but a few acres of alfalfa have been dependent upon it for water.

Bacigalupi Ditch.—Southward from Bayou, on the north side of the main channel of Tule River, is another high-water ditch, which has been in use more or less since about 1882. It is a short private ditch which supplies water for use on several hundred acres of land.

Bacigalupi & Creighton Canal.—This canal was constructed, in part at least, in 1877. It is really a diversion from Elk Bayou, the southernmost delta channel of Kaweah River, but as Lower Elk Bayou may also be considered a Tule River channel, receiving water from Porter Slough and being the main channel of Old Tule River, it will not be out of place to enumerate this canal among the Tule River ditches, particularly as the flow of Main Tule River into the lower end of Elk Bayou is chiefly relied upon as a source of supply for this ditch. The head of the ditch is on the north side of the bayou, about a quarter of a mile above its junction with the main channel of Tule River. The canal has a northwesterly course for about 4 miles, thence a southwesterly course for a like distance to near the eastern margin of Tulare Lake. It was built primarily for the reclamation of land entered as a desert claim. The regulator built in the head of the canal was soon washed out of place and the upper end of the original canal was considerably enlarged by erosion. The upper part of the canal was originally about 8 feet wide

on the bottom, but a width of 12 feet on the bottom, with a water depth of 2 to 3 feet, is claimed for most of its course. So far as can be learned, there has been but little systematic irrigation in the territory commanded by this canal.

Tulare Lake Canal.—This canal, which was built in 1890, takes water from Tule River at a point 10 miles due west from Tipton. It has a bed width of 40 to 50 feet and a depth reported at 4 to 5 feet. It lies within the extreme high-water limit of Tulare Lake. Its course is due south and its length is 3 miles. It commands the lands westward to the present lake margin. Water is expected to be available in this canal from about February to July. It is reported to have supplied water this season to 7,000 acres of grain land. At the head of the canal structures of the ordinary open flashboard type are in use for the diversion and control of the water. The cost of the canal head works is said to have been $3,000, and the cost of the main canal and 10 to 15 miles of branch ditches, including the head works, was about $10,000.

TULE RIVER IRRIGATION DISTRICT.

In no portion of the State has the necessity for harmonizing conflicting claims to water and adequate control of its diversion and use been greater than on Kaweah and Tule rivers, and it is on these rivers that the successful operation of the irrigation-district system was to be anticipated. It seemed as though all irrigators could only gain, and none lose, by bringing the many small independent ditches under one management, as authorized by the district law. And, in fact, no difficulty was encountered in forming on Tule River two irrigation districts, both of which have constructed canal systems, but in both of which there is now much dissatisfaction with the operation of the law and with the results thus far achieved. Of course the disappointments and failures are, in part at least, due to the general depression of the farming industry; but with an increasing tax rate as a burden upon those who meet their district obligations, and with probable confiscations of the property of those who continue delinquent, the problem of district management becomes difficult of solution.

The Tule River irrigation district was organized in September, 1891. A bond issue of $90,000 was soon followed by a second of $10,000. The district has an area of about 22,000 acres—practically all the lands within or immediately adjacent to the delta of Tule River. The district has a greatest length in the direction of the river of 13 miles, its eastern limit being about 6 miles west of Porterville, and a breadth of about 4 miles. Some of the land within exterior boundaries has been excluded.

The entire bond issue has been expended in completing the canal system. The bonds could not be sold readily and were finally, through the hands of a nominal purchaser, turned over to the contractors, who carried on operations by hypothecating them. The canal system consists of a main water way to and into the district—Porter Slough—and

two principal laterals, one on each side of Tule River. At the head of Porter Slough a cut 700 feet long has been made from the river into the slough. In this cut a regulating gate 36 feet wide has been placed, which is intended to serve the irrigation-district canal as well as the Hubbs & Miner Ditch. Of its 9 bays or openings, 7 are for the district and 2 for the other ditch. After flowing in Porter Slough for 7 or 8 miles the district water is taken into a large canal whose head is 3 miles west of Porterville, and which has a westerly course for 2½ miles to a point near the north bank of Tule River. The water is there separated into two canals, of which one has a northerly course back to Porter Slough and the other drops its water into Tule River, from which it is again reclaimed half a mile below. Porter Slough is the main north-side lateral for 6 or 7 miles; thence an artificial canal continues westward to near the western limit of the district. The south-side main lateral has a course almost due west for 11 to 12 miles, holding a position within one-half mile to a mile of the south boundary of the district. The older ditches within the district and smaller laterals complete the distributing system. The dropping of the south-branch water into Tule River is only a temporary arrangement, it being proposed to carry this water over the river in a flume.

Water is expected in the district canals from about March 1 to July 1. The irrigators are this season allowed to take water as they please, canal operation being blocked by litigation. It was at first proposed to meet operating expenses by levying an assessment upon the property of the district. This was done one season, and cost of operation was about $2,000. The following year, 1896, water was sold at 20 cents per irrigating head per hour, the head of water being understood to mean the amount which would pass over a clear overfall 4 feet long and 1 foot deep. This year, as already stated, water is taken by irrigators as they can get it.

TIPTON IRRIGATION DISTRICT.

The Tipton irrigation district is a second district dependent upon Tule River for its water supply, but its right to make a diversion extends only to the flood flow of the river. This district was organized in 1891. It contains 17,040 acres, located on the south side of Tule River, south of the lower portion of the Tule River irrigation district. A first issue of bonds of $50,000 was followed by a second to the amount of $20,000, but the second series has never been disposed of.

The district receives water through Callison Slough, the southernmost delta channel of Tule River. Arrangements were made with the Woods Central Irrigating Ditch Company whereby a regulating gate was to be placed and maintained for common use in the head of the slough. This was done. The gate was made 30 feet wide, 20 feet for the irrigation district, and 10 feet for the Woods Irrigating Ditch. The main

district canal was taken out of the slough about 2½ miles below its separation from the river. It reached the district by a course a little south of west, and four principal laterals were extended from it westward into the district.

The canal system cost the district $50,000 in bonds and an additional $11,000 represented by outstanding warrants. Here, as in other districts, bonds did not sell readily for cash at or above the limit prescribed by law, and here too the bulk of them went to the contractors of ditch work through a nominal purchaser.

The tax collector of the district has been temporarily enjoined from selling property for delinquent taxes. The residents of the districts do not seem able to pay the irrigation tax, which has been from 3 to over 4 per cent per annum. The operating expenses, including salaries of all officials and employees, were about $3,000 while the district was still in operation. Irrigation has therefore been extended very little, if any, under the district system, so that on the whole the outlook for this district is not encouraging.

METHODS OF IRRIGATION.

Irrigation from Tule River, with its many channels of slight depth, is very readily accomplished; so easily, in fact, that most of the farmers along its banks have in the past drawn its water through small ditches, generally owned in common by several irrigators. Small high-water ditches, frequently without head gates, are numerous, and there are but few irrigation works on a large scale. The dams in use to divert the water into the heads of the ditches are usually temporary structures of sand and brush. The only ones which are expected to withstand the freshets are those at canal heads above Porterville. The banks of Tule River are so low that but little cutting is required to carry water from the point of diversion away from the river banks. Only the lands near and above Plano and Porterville, and those along the Farmers' Canal, are favored with water for irrigation during more than the spring months.

Crops cultivated above Porterville are principally fruits, including citrus fruits, for which this section is famed, vegetables, and other summer crops. Below Porterville the most important crop irrigated is alfalfa. Most of the irrigated land near Porterville and Plano, where not in the river bottom, is a moderately dark loam. Water is applied to trees, vines, and vegetables in furrows run between rows. The slope of the ground in the region just indicated is ordinarily too great to permit of irrigation by any of the systems of flooding in checks, as elsewhere practiced. When irrigating in furrows, the water is delivered into a number of these at the same time from a small distributing ditch. The quantity of water admitted into each is so small that it does not cause erosion. As soon as the loose soil between furrows is thoroughly wet, irrigation is complete and water is turned off.

This system of irrigation was observed on a hillside about 1 mile east of Porterville. Water was diverted from a branch of the Pioneer Canal into a small distributary lying along the upper edge of the orchard to be irrigated. The amount used as an irrigating head was about half a second-foot. From the distributing ditch the water was diverted at regular intervals through small tubes of tin, stuck through short boards and placed temporarily into the side of the ditch; thence it found its way into the furrows. The grade of the furrows was about 1 foot in 20. The water was allowed to flow in thirty furrows at the same time and required the attention of one man. Constant attendance was required, but the labor was very light. This system of irrigation can be practiced to advantage only in the daytime. The furrows were about 3 feet apart; there were three furrows between each two rows of trees.

By means of this system of irrigation the ground was wet to a depth of 3 feet or more. After a few days the ground was well cultivated, in order to reduce the loss of water from the surface by evaporation. The soil of the tract thus irrigated is a light black loam, a dry bog, which becomes very soft and sticky when wet. The proprietor gave his vines and trees only one irrigation per annum. The average annual rainfall in this vicinity is about 11 inches. It is less at points farther west, being only about 7 inches along the central line of San Joaquin Valley at points opposite Porterville.

Lands along Tule River west of Porterville are for the most part level and have a smooth surface. Irrigation is generally accomplished by flooding in checks having an area of only a few acres each. Alfalfa is irrigated every four to six weeks while water is available; orchards and vineyards, once or twice a season, according to water supply; corn land, ordinarily once before seeding; and vegetables, almost continuously during the time water is available. Every ditch owner tries to keep water in his ditch as long as possible, because it is useful for stock purposes when not required for irrigation. The soil along the river is generally a sandy loam, usually resting on firm clay, called hardpan, found at a depth of 1 to 6 feet. Ground water near the river is about 14 feet; it is to some extent affected by the flow of water in the river and in ditches and its use in irrigation; but the time between irrigation periods is so long that the water table has not been permanently raised in consequence of irrigation. Irrigation has produced no marked changes in the character of the soil, though it is occasionally claimed to have been the cause of an increase of alkali at the surface of some of the lands irrigated. Fevers are, and always have been, prevalent to some degree along Tule River, and it is not possible from the limited data collected to determine to what extent the healthfulness of the country has been affected by the practice of irrigation.

Private ownership of ditches has been the rule on Tule River. The sale and measurement of water is now, however, about to become

an established fact on the Pioneer Canal, and has already been introduced in the Tule River irrigation district; but it practically amounts only to systematizing water distribution, compelling economic use, and putting the burden of canal maintenance upon the irrigator alone, the sale being restricted either to holders of canal stock or to taxpayers in a district.

PUMP IRRIGATION AT LINDSAY.

The water development by means of artesian wells in San Joaquin Valley is a subject of considerable interest, but can not be dealt with fully in this paper, owing to lack of detailed information concerning recent developments. But the use of water secured by pumping from a subsurface source has been so successful, in at least one portion of the field under consideration, that a brief reference to it will not be out of place.

Lindsay is a new settlement on the east-side valley plain, about 10 miles northwest of Porterville. It was at first proposed to bring water into that locality from Kaweah River, but before the difficulties in the way of canal construction were overcome it was found that a layer of sand at about 60 to 65 feet below the surface afforded a fair supply of water. Centrifugal pumps have been brought into service to develop this water supply. The pumps are placed in pits about 30 feet deep, near the surface of the ground water, and water is delivered by them through pipes to the place of use. Both steam and gasoline engines are in use to supply power. The irrigation is confined almost exclusively to citrus fruits, the cultivation of which commenced in this locality about five years ago. The water surface in the wells is lowered during pumping from 10 to 27 feet, according to pump capacity. The total height water is raised, including friction in pipes, is said to exceed in some cases 70 feet. One irrigator, with 2¼ cords of oak wood at $4 a cord, and one pump, claims to be able to irrigate from 20 to 25 acres of orchard land per day, according to distance from pump. The method of irrigation is by multiple furrows between rows of trees. The soil is a rather stiff, chocolate-colored loam.

There are four steam pumping plants and about six gasoline pumping plants now in that vicinity.

Irrigation is continued throughout the summer months from about May 1 to October 1. Trees over one year old receive water every five to six weeks; younger trees more frequently.

INDEX.

	Page.
Alta irrigation district, situation and organization of	24
Anderson Canal, description of	48–49
Arujo Ditch, description of	43
Ashe Ditch, description of	60
Bacigalupi Ditch, description of	89
Bacigalupi & Creighton Canal, description of	89–90
Bakersfield, examples of irrigation near	69–70
Ball & Harris Ditch, description of	82
Bond Ditch, description of	89
Beardsley Canal, description of	50–51
Browns Valley irrigation district, notes on	23–24
Buena Vista Canal, description of	49
Callison Slough, description of	81
Calloway Canal, description of	51–55
Carothers Ditch, description of	76
Castro Ditch, description of	48
Central irrigation district, location and area of	23
Cereals, furrow irrigation of	32
Checks (level), furrow irrigation in	33
College City irrigation district, location of	23
Colusa irrigation district, location and area of	23
Cost of preparing land for irrigation	67
Creasey Ditch, description of	75
Creech Ditch, description of	83
Deer Creek, irrigation from	76
Deer Creek Consolidated Ditch, description of	76
Dixon Canal, description of	61
Duty of water, examples of irrigation showing	69–75
Edwards Ditch, description of	58
Elrod Ditch, description of	88
Empire Ditch, description of	82
Emery Ditch, description of	55
Fancher Ditch, description of	83
Farmers Canal, description of	47
Farmers Ditch, description of	85
Fine Ditch, description of	80
Finney Ditch, description of	83
Fisher & Abley Ditch, description of	48
Flooding between parallel levees, description of	31–32
Flooding in contour checks, description of	27–29, 66
Flooding in level checks, description of	30–31
Flooding in rectangular checks (not level), description of	29–30
Frazier Ditch, description of	50
Fulweiler Ditch, description of	88
Furrow irrigation, description of	32–33
Gates Canal, description of	49
Gilliam Ditch, description of	87
Goose Lake Canal, description of	56
Great American Ditch, description of	84
Gully Ditch, description of	83
Henley Ditch, description of	50
Hively Ditch, description of	83
Hockett Ditch, description of	87
Hubbs & Miner Ditch, description of	87–88
Hunsaker Ditch, description of	88
Huron irrigation district, location of	25
Irrigation, methods of	26–36, 66–68, 92–94
State control and legal regulation of water supply for	19–22
Irrigation districts, details concerning	23–25
James Canal, description of	49–50
James & Dixon Canal, description of	58–59
Johnson Canal, description of	59–60
Joice Canal, description of	60–61
Jones Ditch, description of	83
Jones & Tuckey Ditch, description of	56
Kern and Tulare irrigation district, notes on	25, 63
Kern Island Canal, description of	43–45
Kern River, hydrography of	37–41
irrigation from	42–75
Kern Valley Water Company's canals, description of	61–63
Klein Ditch, description of	89
Kraft irrigation district, location of	23
Lamarsna Ditch, description of	89
Legal regulations of use of running water, methods of	19–22
Level checks, furrow irrigation in	33
Lindsay, pump irrigation at	94
Lone Oak Slough, description of	83
Madera irrigation district, location and area of	24
May Ditch, description of	60
McCaffery Ditch, description of	51
McCord Canal, description of	51
McGee, Putnam, & Caldwell Ditch, description of	87
Meacham Canal, description of	50
Mitchell, Springer, & Rose Ditch, description of	79
Modesto irrigation district, location and area of	24
M. M. Burnett Ditch, description of	88–89
Measurement of water, modes of	65–66
Newell, F. H., letter of transmittal by	11
Old English Ditch, description of	81
Old South Fork of Kern River, description of	46–47

	Page.
Orchards, furrow irrigation of	32–33
Orland South Side irrigation district, location and area of	23
Panama Slough, description of	47
Pierce & Barker Ditch, description of	43
Pioneer Canal, description of	57–58, 84–86
Plano Ditch, description of	79
Pleasant Valley Ditch, description of	84
Pletts Ditch, description of	88
Plunkett Ditch, description of	50
Porter Slough, description of	86–87
Porterville, irrigation near	92–93
Poso Creek, irrigation from	75–76
Poso irrigation district, notes on	25
Purcell Ditch, description of	75
Railroad Canal, description of	56
Ray & Brown Ditch, description of	88
Rio Bravo Ranch canals, description of	42–43
Rogers Upper Ditch, description of	89
Rogers Lower Ditch, description of	83
Rose Ditch, description of	79
San Joaquin Valley, area, general character, and hydrography of	15–18
Sausalito Ditch, description of	76–77
Schuyler, J. D., cited on cost of preparing land for irrigation	67
cited on duty of water	69, 71
Selma irrigation district, location of	24
Soils, characters of	41–42
South Fork of Kern River, description of	46–47
South Side Tule River Canal, description of	79–80
South Tule River Ditch, description of	78–79
Statutory provisions governing use of running water	19, 22
Stine Canal, description of	48
Stockton Ditch, description of	81–82
Subsoil irrigation, methods of	33, 36
Sunset irrigation district, location and area of	25
Swall Ditch, description of	83
Swall & Wessling Ditch, description of	84
Thomas Ditch, description of	88
Tipton Ditch, description of	82–83
Tipton irrigation district, notes on	25, 91
Traylor Ditch, description of	86
Trees, furrow irrigation of	32–33
Tulare irrigation district, work in	24–25
Tulare Lake, fluctuations of level of	16–17
Tulare Lake Canal, description of	90
Tule River, description of	78
irrigation from	78–94
methods of irrigation from	92–94
Tule River irrigation district, notes on	25, 90–91
Turlock irrigation district, work in	24
Vandalia Ditch, description of	79
Vegetables, furrow irrigation of	33
Vines, furrow irrigation of	32–33
Vineyards, furrow irrigation of	32–33
Wallace Ditch, description of	87
Warren, A. K., cited	38
Water, duty of	69–75
modes of measurement of	65–66
prices of	65
State control and legal regulation of use of	19–22
Wible Canal, description of	56
Wilcox Ditch, description of	79
Wild flooding, description of	26–27
Wilson Canal, description of	50
Winfield Ditch, description of	76
Woods Central Ditch, description of	81
Woodville Ditch, description of	83
Wright law, features of	20–21

O

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian areas of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

1898.

Nineteenth Annual Report of the United States Geological Survey, 1897–98, Part IV, Hydrography, 1898; octavo, — pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton; and "Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1898.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by T. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas, by William Ferguson Hutson, 1898.
14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.

In press:

18. Irrigation near Fresno, California, by C. E. Grunsky.
19. Irrigation near Merced, California, by C. E. Grunsky.
20. Experiments with windmills, by Thomas O. Perry.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896-97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved, June 11, 1896; Stat. L., vol. 29, p. 453.)

The maximum number of copies available for the use of the Geological Survey is 1,000. This number falls far short of the demand, so that it is impossible to meet all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or donation of data. Requests specifying a certain paper and stating a reason for asking for it are attended to whenever practicable, but it is impossible to comply with general requests, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 18

IRRIGATION NEAR FRESNO, CALIFORNIA.—GRUNSKY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation, prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1889.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 68 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey" by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 18

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

IRRIGATION NEAR FRESNO, CALIFORNIA

BY

CARL EWALD GRUNSKY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

CONTENTS.

	Page.
Letter of transmittal	9
Kaweah River	11
Hydrography	11
Canals and ditches	14
Wutchumna Canal	14
Curtis & Lindsey Ditch	16
Venice Ditch (North Side Rocky Ford Ditch)	16
Elbow Ditch No. 1	16
Matthew Ditch, or Elbow Ditch No. 2	16
Curtis Ditch	17
Weston Ditch	17
Uphill Ditch	17
Settlers Ditch	17
Lakeside Ditch	18
Jennings Ditch	20
Rodgers Ditch	20
Modoc Canal	20
Hicks & Weston Ditch	20
Hayes Upper Ditch (Goshen Ditch)	20
Hayes Lower Ditch	21
Pogues Upper Ditch	21
Pogues Lower Ditch	21
Ogden Ditch	21
Hamilton Ditch	22
Consolidated Peoples Ditch	22
Swanson Ditch	25
Lee & Thompson Ditch	25
Rice Ditch	25
Catron and Teague ditches	25
Bliss & Hyde Ditch	25
Davis, Brown, and Pennebaker ditches	25
Extension Ditch	25
Kaweah Canal	26
Farmers Canal	27
Tulare Canal	28
Rocky Ford Ditch	29
Cameron Creek Company	29
Bacon & Crossmore Canal (Packwood Creek Canal)	29
Judd Ditch	30
Cutler & Higgins Ditch (Chatten Ditch)	31
Kaweah and Mill Creek Water Company	31
Oaks Ditch	31
Evans Ditch	32
Evans & Turner Ditch	32
Burch Ditch	32

Kaweah River—Continued. Page.
Canals and ditches—Continued.
Watson Ditch 32
Mill Ditch 32
Bahwell and Fulgham ditches 33
Longs Canal 33
Bostwick Cut 33
Ketchum Cut 34
Crowley & Mehrtens Ditch 34
Tulare irrigation district 34
Water supply, soils, and methods of irrigation 35
Kings River 39
Hydrography 39
Canals and ditches 42
Kings River & Fresno Canal 42
Fresno Canal 43
Centerville Ditch 47
Sweem Ditch 48
Fowler Switch Canal 48
Centerville & Kingsburg Canal 50
Selma irrigation district 52
Alta irrigation district (76 Canal) 52
Morrow Ditch 57
Dennis & Jordan Ditch 57
Kincaid Ditch 57
Glenn and Barton ditches 57
Emigrant Canal 57
Liberty Canal 58
Millrace Canal 58
Reeds Ditch 58
Laguna de Tache Canal (Grant Canal) 58
Crescent Canal 62
Peoples Ditch 62
Mussel Slough Ditch 64
Last Chance Ditch 65
Lower Kings River Canal 67
Rhoads Canal 69
Jacobs Canal 69
Sunset irrigation district 69
The Fresno plains 71
Description 71
The canal system 73
Loss of water by evaporation and seepage 74
Effect of irrigation on the water table 78
Methods of irrigating and duty of water 79
Wildflower 85
Liberty and Millrace settlements 86
Laguna de Tache Rancho 86
Mussel Slough country 87
Description 87
Canal system 87
Method of irrigation 88

ILLUSTRATIONS.

		Page.
PLATE	I.—Map showing canals from Kaweah and Tule rivers	11
	II.—*A*, Flume over Tulare Canal; *B*, Main canal of Tulare irrigation district	28
	III.—*A*, Canal regulator, Tulare irrigation district; *B*, Lateral, 1 mile south of Tulare	34
	IV.—Map of east side of San Joaquin Valley, from Kings River to Fresno River	38
	V.—Kings River at upper end of Centerville Bottoms, looking upstream	42
	VI.—*A*, Regulator on Kings River & Fresno Canal; *B*, Fowler Switch Canal near Sanger, looking upstream	44
	VII.—Cobblestone and brush dam of Fresno Canal, Kings River	46
	VIII.—Regulator of Fresno Canal on Kings River: *A*, As seen from above; *B*, As seen from below	48
	IX.—Regulator on Fowler Switch Canal: *A*, As seen from above; *B*, As seen from below	50
	X.—Regulator on 76 Canal: *A*, As seen from above; *B*, As seen from below	52
	XI.—*A*, Furrow irrigation for citrus fruits; *B*, Check weir in Alta irrigation district, in lateral, about 2 miles west of Traver	56
	XII.—Lower Kings River canal system	58
	XIII.—Peoples Ditch: *A*, Brush dam at time of high water; *B*, Regulator, as seen from above	62
	XIV.—Last Chance Canal regulator: *A*, As seen from upper side; *B*, As seen from below	66
FIG.	1.—Head of Wutchumna Canal	15
	2.—Head of Uphill Ditch	17
	3.—Head of Lakeside Ditch	19
	4.—Head of Consolidated Peoples Ditch	22
	5.—Ditch system at head of Kaweah Canal	26
	6.—Head of Farmers Canal	28
	7.—Head of Bacon & Crossmore Canal	30
	8.—Head of Bacon & Crossmore Cut	30
	9.—Discharge of Kings River at Red Mountain, California, 1896	41
	10.—Head of Kings River & Fresno Canal	42
	11.—Head of Fresno Canal	44
	12.—Head of Fowler Switch Canal	49
	13.—Head of Centerville & Kingsburg Canal	51
	14.—Wahtoke Reservoir, on 76 Canal	53
	15.—Head of 76 Canal	54
	16.—Plan and elevation of regulator for 76 Canal	55
	17.—Head of Grant Canal	60
	18.—Head of Peoples Canal, on Kings River	63
	19.—Head of Last Chance Ditch, on Kings River	66
	20.—Upper section of Lower Kings River Canal	68
	21.—Irrigation by filling subsoils with water, Mussel Slough country	89

LETTER OF TRANSMITTAL.

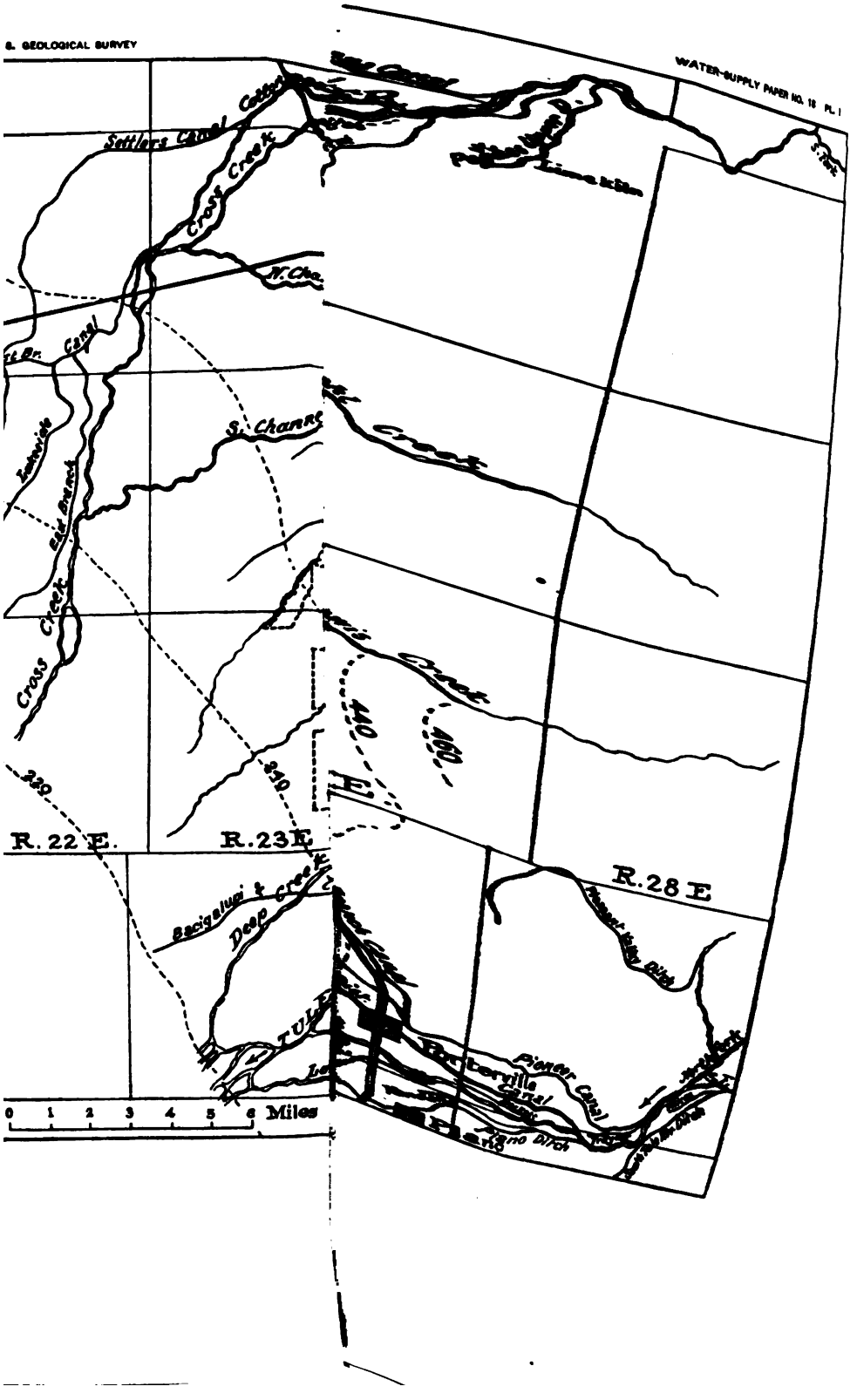
DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, July 6, 1898.

SIR: I have the honor to transmit herewith a manuscript entitled Irrigation near Fresno, California, by Mr. C. E. Grunsky, and to recommend that it be published as one of the series of pamphlets on Water Supply and Irrigation. This is the second of three papers relating to irrigation in San Joaquin Valley, the other two being Nos. 17 and 19 of the series. It relates mainly to the irrigation systems deriving their water supply from Kaweah and Kings rivers, and covering the agricultural lands on the east side of San Joaquin Valley, between Visalia and Fresno.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.


Settlers Canal
Cross Creek
Cross Creek
Deep Creek
Deep Creek
R. 22 E.
R. 23 E.
R. 28 E
Pioneer Canal
Pioneer Canal
0 1 2 3 4 5 6 Miles

IRRIGATION NEAR FRESNO, CALIFORNIA.[1]

By C. E. GRUNSKY.

KAWEAH RIVER.

HYDROGRAPHY.

Kaweah River enters San Joaquin Valley from the east, passing between Dillons Point on the north end and Wutchumna Hill on the south, about 15 miles east of Visalia. Its drainage basin above that point has an area of 619 square miles, mostly low mountain country. The river has a perennial flow, but its flow is comparatively small at low stages, ordinarily about 30 second-feet. The low-water period usually begins in August and continues through January. The river is subject to freshets in the winter months, and is at its highest stages in April, May, and June. Medium stages are expected throughout February, March, and July. The monthly mean flow at the river's highest stage exceeds 4,000 second-feet.[2]

Before the freshets of 1861–62, which have become memorable, the river annually overflowed large areas in its course across the east-side valley plain, and numerous high-water channels carried its waters toward Tulare Lake. The portion of its overflowed district to the east of or above Visalia is generally referred to as Visalia Swamp. Four of the river channels—Elbow Creek, Visalia or Mill Creek, Packwood Creek, and Deep Creek—gave the name of "Four Creek Country" to the vicinity of Visalia. The channel at the northern edge of the overflowed land was known as Canoe Creek above Iron Mountain, and as Elbow Creek below that point. The course of Elbow Creek is north of west to a junction with Cottonwood Creek, a small water course from the northeast, thence southwesterly to a reunion with Kaweah River water in Cross Creek, which name is given to the lower portion

[1] For an account of irrigation in other parts of San Joaquin Valley, see Water-Supply and Irrigation Papers Nos. 17 and 19. These three papers are based largely upon information collected by the State engineering department of California ten years ago, and are intended to supplement the two volumes issued by that department, namely: Irrigation Development, History, Customs, Laws, etc., in France, Italy, and Spain, by Wm. Ham. Hall, C. E., State Engineer, Sacramento, California, 1886; and Irrigation in California (Southern), Part 2 of Report of Wm. Ham. Hall, C. E., State Engineer of California, 1888. (See introductory paragraph on page 13 of Water-Supply and Irrigation Paper No. 17.)

[2] Physical Data and Statistics, Wm. Ham. Hall, State Engineer of California, pp. 455, 476.

of St. Johns Channel of the river. Deep Creek was the principal south marginal stream. It received water from the main channel of the river 8 miles east of Visalia and lost its identity about 5 miles southeast of Visalia, where its waters spread and were received into other channels of different names. Visalia Creek and Packwood Creek were the names given to the two water courses into which the main channel of Kaweah River separated 5 miles above Visalia. The course of Visalia Creek was westerly through Visalia, that of Packwood Creek southwesterly. To understand the changes made in the system of principal channels of the river by the high waters of 1862 and the effects of these changes, it is necessary to know that, even preceding that year, irrigation and drainage work had been done in the Kaweah River delta. The Shipp Cut had been made in 1854. It was a small drain ditch from the swamp, near where Rocky Ford now is, southwesterly to a connection with Canoe Creek. A canal had been constructed from Visalia Creek into Visalia to supply power to a flour mill. The Lander Ditch, the Watson Ditch, and a number of other small ditches from Visalia and Packwood creeks had also become dependent upon the flow of water in the river channels at the south of Visalia. The freshets of 1861–62 cut a new channel from a point on Kaweah River about 14 miles east of Visalia in a northwesterly direction toward and along the northern border of Kaweah River Swamp. Shipp Cut and a section of Canoe Creek were enlarged by the flood waters and became a part of this new channel, and finally a connection was established with the Cross Creek channel below Visalia, and thus St. Johns Channel of Kaweah River was permanently established. At the same time a new high-water channel was washed out toward the northeast from a point on Kaweah River 6 miles above Visalia to a connection with this new channel. This is known as Sand Slough, which still remains as a connection between the two river channels at a point where they are only about one-half mile apart. The same high waters caused so much erosion in Landers Ditch that it became a branch of the river, and is generally referred to as Landers Slough. Its upper portion was long in use as the channel through which the Consolidated Peoples Ditch received its water.

The upper sections of the original main channel of Kaweah River were obstructed by the drift and silt deposits of these freshets, and as the low-water period of 1862 approached, it was found that water was scarce for those depending upon Deep Creek, Packwood Creek, and Visalia Creek for their supply, and many projects were proposed for relief. During the years immediately following, a number of ditches were constructed from the St. Johns Channel of the river, near Rocky Ford, southwesterly to the original main channel. Such were Longs Canal, Ketchum Canal, and the Bostwick Cut. All of these were intended to increase the flow in the delta streams at and southward of Visalia. After much contention between settlers on these several streams as to

the apportionment of their scant supply of water, it was agreed, in 1867, that a gate should be constructed in the head of Visalia Creek. This gate was not, however, maintained long. The freshets of 1867–68 were almost equal to those of 1861–62 and effected further enlargement of the St. Johns Channel. They refilled and otherwise destroyed some of the ditches that had been opened as connections between the two rivers. They washed out the gate in the head of Visalia Creek, and partially closed the heads of Packwood and Deep creeks. They enlarged Sand Slough. At the same time the upper portions of the old channel of Kaweah River were further obstructed by drift and silt, and a new head of St. Johns Channel was eroded about a mile above the former point of separation of the two channels.

To overcome the increased difficulties of keeping a good supply of water in those channels of the river reaching the vicinity of Visalia, many ineffectual efforts were made and much money was almost uselessly expended until, in 1877, a contract was entered into with Mr. Samuel Fowler by the Kaweah Canal and Irrigation Company, the Consolidated Peoples Ditch Company being an interested party, to open the old channel of the river. The cut then made, practically following the old channel, was enlarged and deepened by erosion, until a few years thereafter it was again the low-water channel of Kaweah River. Another obstructed section of the old channel near the head of the Consolidated Peoples Ditch, about 10 miles east of Visalia, was improved about the same time by the Kaweah and Mill Creek Water Company, and has since been known as the Visalia Cut or Hamilton Cut.

The obstructed head of Packwood Creek was improved by the Rocky Ford Canal Company, but was not in service long. This creek now receives its principal supply of water through the Bacon & Crossmore Cut from Visalia Creek. It has a southwesterly course, and such of its water as is not used for irrigation is delivered into Tulare Lake.

Cross Creek has already been mentioned as receiving the water of St. Johns Channel, Elbow Creek, and Cottonwood Creek. After approaching within 4 miles of Traver its course becomes southwesterly to a union with some of the old high-water delta channels of Kings River. Its course is thence southerly along the eastern border of this delta to Tulare Lake, which receives its water.

Visalia or Mill Creek separates into two channels soon after passing through Visalia. The course of one of these is a little north of west, that of the other southwest. Both unite with Cross Creek before reaching Tulare Lake.

Cameron Creek is one of the lesser delta channels of Kaweah River. It receives a portion of the flow of Deep Creek at a point about 6 miles due east from Visalia, and has a southwesterly course to Tulare Lake. It passes just to the northward of Tulare. An artificial channel at the head of this water way, constructed to improve its connection with Deep Creek, was closed by an order of court some years ago.

Deep Creek has already been mentioned. Its waters at the spread or sink of the creek were conducted by small artificial channels into Lower Deep Creek and Bates Slough. These artificial channels were soon so enlarged by erosion that the two lower sloughs have become extensions of the Deep Creek channel and conduct its waters onward southwesterly toward Tulare Lake.

Outside Creek has a course along the eastern margin of the Kaweah delta. The creek can not be traced to a direct connection with the present river channels. It may, in fact, be regarded as the extension into the river delta of Yokohl Creek, a small stream draining a portion of the foothill section intermediate between the Kaweah River and Tule River drainage basins; but in times of flood the natural flow of some of the river water was into depressions, reaching a point that may be regarded as the head of Outside Creek, about 9 miles east of Visalia. The creek now receives an occasional inflow of foothill drainage waters from the east and the waste water from some of the branches of the Consolidated Peoples Ditch. The water of Outside Creek is distributed to a number of channels, the most southerly of which is Elk Bayou, which unites southeast of Tulare with the old channel of Tule River, and thence has a southwesterly course to a union with the present main channel of Tule River.

CANALS AND DITCHES.

Wutchumna Canal.—This is the upper north-side diversion of water from Kaweah River. The head of the canal is at the base of the slope of Dillons Point, a foothill spur rising to the northward. Thence it has a westerly course for 4 miles to a flat depression, which its water converts into a lake of about 40 acres, known as Bravo Lake. Leaving Lake Bravo, the westerly course of the canal is maintained 4 miles farther to the northern base of Iron Mountain, and thence 6 miles southwesterly to St. Johns Channel, about 4 miles above Visalia, where its water is carried over the river channel in a flume. The main canal then flows westerly near the south bank of the river about 2 miles to a junction with Old or Lower Wutchumna Ditch, whose branches extend far to the west of Visalia.

The Wutchumna Water Company was incorporated in 1872 for the avowed purpose of effecting a better distribution of water to the several ditches dependent upon Kaweah River for their supply, but various difficulties were encountered which prevented the enterprise from meeting with anticipated success, and it was not until 1880 that a connection between the upper diversion—work on which is reported to have commenced in 1872—and the distributing system of the lower canal was finally established. The lower canal was constructed in 1873 or 1874. Its head is on the south side of the St. Johns Channel of Kaweah River, about 3 miles northeast from Visalia. It established a direct southerly connection between St. Johns River and Visalia Creek,

and for three years its water furnished power for the flour mill in Visalia. The principal branch of the Lower Wutchumna Canal has a westerly course, passing just to the north of Visalia and terminating at a point about 4 miles south from Goshen.

The first work at the head of the Wutchumna Canal seems to have been done by Stephen Barton, who subsequently appears as one of the directors in the Pioneer Canal Company, which was incorporated in 1877, and which during that season constructed a ditch on the line adopted by the Wutchumna Canal as far as Bravo Lake. When the Wutchumna Canal Company, as successor of the Pioneer Company, assumed control, this upper ditch was extended along the route already described.

The canal head gate or regulator has been placed in a rock cut, and, as a result of this location of the head of the canal, expenditures of maintenance became unusually heavy when, a few years after the canal came into use, it became necessary to cut the upper section of the canal 4 feet deeper. This was done at a cost of $6,000. The total cost of canal construction has probably exceeded $60,000. The head gate width is 20 feet, and this may be regarded as the average bed width of the canal throughout its principal section. Its fall is reported to be nearly 7 feet to the mile for 4 miles, thence 2½ feet to the mile. The flume across St. Johns River is 14 feet wide, 2 feet deep, and about 150 feet long. It was built in 1880. The head gate of the Lower Wutchumna Canal is a little over 11 feet wide.

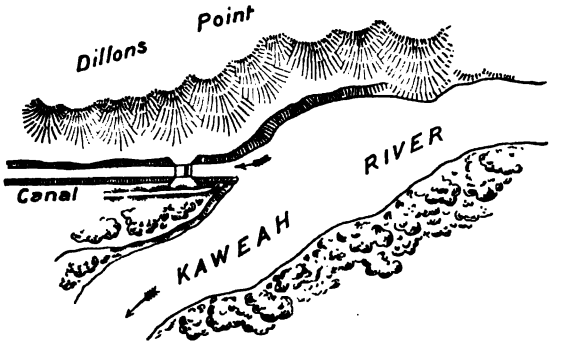


FIG. 1.—Head of Wutchumna Canal.

For a distance of about 4 miles westward from Lake Bravo the canal follows the original alignment of the Curtis & Lindsey Ditch. This ditch was enlarged, and its owners were granted a right to use that section of the Wutchumna Canal.

The canal is owned by an incorporated company whose shares are all in the hands of about thirty persons. All canal expenses are met by assessment of the stockholders. Each stockholder is entitled to a proportional part of the water in the canal, and he may dispose of this at his pleasure. He may lease this to whom he pleases, but not in less amounts than full shares. The distribution of water is in charge of a canal superintendent, who apportions it to the various distributing ditches in proportion to the number of shares represented in each. Although the company owns some of the shares of stock, these are not

for sale, nor will the company lease them or the water which they represent. By retaining these the company increases the proportional part of water represented by each of the other shares. The canal company bears the expense of the necessary structures at the heads of distributing ditches, but does not keep them in repair or replace them if destroyed. This has to be done under direction of the canal superintendent by the parties directly interested in their maintenance.

Curtis & Lindsey Ditch.—This ditch has its head on the north side of St. Johns River, 4 miles below the head of the Wutchumna Canal. It has a northwesterly course for one-half mile to a connection with the Wutchumna Canal, into which it drops its water. Four miles below this point the water dropped into the Wutchumna Canal is again taken out by a ditch 4 miles long having a northwesterly course and terminating on the bottom lands of Cottonwood Creek. The Curtis & Lindsey Ditch was constructed in 1876, and its extension toward Cottonwood Creek was made in the following year. Soon afterwards 4 miles of its course were adopted as the alignment for the Wutchumna Canal, so that the ditch now appears in two sections, of which the lower one may also be considered a branch of the Wutchumna Canal. The ditch is also known as the Curtis, Lindsey & Moffitt Ditch. Its width was about 10 feet on the bottom, and its fall between 2 and 3 feet to the mile, but, so far as known, the extent of irrigation from it has not exceeded several hundred acres.

Venice Ditch.—This, called also North Side Rocky Ford Ditch, is a small north-side ditch which seems to have been first used about 1873. It was extended and enlarged somewhat in 1877. Its head is at Rocky Ford. It has a westerly course to Iron Mountain, thence skirts the eastern and southern base of this mountain, and terminates 2 miles farther west. It is about 6 miles long and 3 to 8 feet wide. Ownership in the ditch is represented by shares held by the farmers who use its water.

Elbow Ditch No. 1.—The flow of Elbow Creek, which leaves St. Johns River at a point about 5 miles above Visalia, is controlled, in a measure at least, by a regulator or head gate 8 feet wide, and is frequently referred to as Elbow Ditch No. 1. The upper part of the creek is an enlargement by erosion of a portion of the ditch known as Shipps Cut, which was constructed in 1854.

Matthew Ditch, or Elbow Ditch No. 2.—This is a small ditch having its head on the north side of St. Johns River, about 2 miles below the head of Elbow Creek. It was constructed in 1855, but with a somewhat different alignment from the present. The freshets of 1861–62 so changed the position and character of Kaweah River that the head of the ditch had to be carried upstream. It is difficult to determine whether the ditch remained in continuous use. The head gate was put into the new ditch in 1875 and was set somewhat lower than the bed of the river. A few years later erosion had progressed in

the river channel to such extent that a wing dam had to be used to divert water into the ditch. The ditch has a northwesterly course, is about 6 miles long, 6 feet wide on the bottom, carries water about 1½ feet deep, and has a grade of about 6 feet to the mile. It irrigates between 200 and 300 acres, of which nearly one-half is alfalfa.

Curtis Ditch.—About 1879 there was a small ditch in use occasionally for the irrigation of a few acres of alfalfa on the north side of St. Johns River about a mile below the head of the Matthew Ditch. It was known as the Curtis Ditch, and has fallen into disuse.

Weston Ditch.—Another abandoned small ditch which was in use for a few seasons prior to 1880 on the north side of the river, about a mile above the head of the Uphill Ditch, was the Weston Ditch.

Uphill Ditch.—This is another north-side ditch. Its head is half a mile above the road leading northward from Visalia. Diversion is made from the river without the use of any permanent weir. The diverted water is led in a cut a few hundred yards northwesterly and is dropped into a natural depression or high-water channel, in which it continues on the same course half a mile. Thence it is taken in the ditch proper northerly about 3 miles to the place of use in the vicinity of Elbow Creek. The head gate is 8 feet wide. It is in the form of a box culvert, and bears a heavy fill of sand on top, intended to give it stability. The sand deposits in the cut to the river above the head gate have made it somewhat expensive to keep the head of the ditch open. The ditch was constructed in 1871. It was made 8 feet wide on the bottom, and was intended to carry water 2 feet deep. Its fall is 20 inches to the mile.

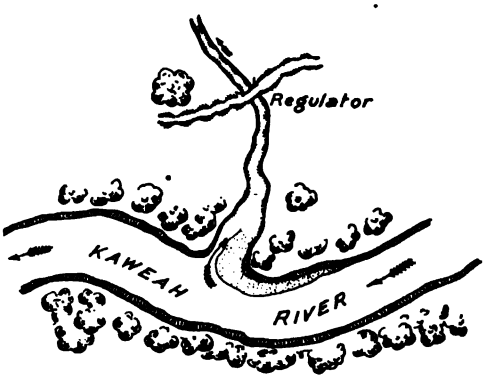


FIG. 2.—Head of Uphill Ditch.

Settlers Ditch.—This is a canal which for many years was of considerable importance as a source of water supply for lands in the eastern part of the Kings River delta. The canal receives water through a branch of Cross Creek. The canal regulator is on the north side of that creek 3 miles south of Traver. The creek channel, there tapped by the canal, is really the extension of Cottonwood and Elbow creeks, but most of its flow comes through a cut, the real head of Settlers Ditch, a quarter of a mile long, leading from the main channel of Cross Creek to its northern branch, at a point about 4 miles above the Settlers Canal head gate. Where the canal is finally diverted from Cross Creek a light timber weir or waste gate has been placed across the

creek channel. The canal regulator is nearly half a mile below the point where the canal leaves the natural channel. The head gate is 32 feet wide. It has eight openings, each 3 feet 6 inches wide in the clear. The gates closing these openings are provided with stems to which power is applied by means of levers.

The canal proper has a bed width at and near its head of 32 feet, and can carry water 2½ feet deep. It has 9 inches fall to the mile, and a capacity of 75 to 80 second-feet. The width of the canal is reduced within 3 miles of its head gate to 24 feet on the bottom, and its fall to 6 inches to the mile. Its course is a little south of west for 5 miles to a point where its water is divided, being carried thence southerly in two channels, of which the easterly branch is about 4½ miles long, and the westerly about 7 miles. The ditch commands a territory of about 8,000 acres, of which as much as 5,000 acres have been benefited by its water in a single season. The canal construction commenced in 1874, and considerable land was irrigated in 1876. Water was available only during the high stages of Kaweah River.

There was but little irrigation with water from this canal at any time to the east of the Kings River delta lands, soils being too alkaline to encourage cultivation. The extent to which this canal is now in use is somewhat problematical, as all the rights to water which it was supposed to have acquired were sold to the Tulare irrigation district, which has made a diversion from the St. Johns River about one-half mile below Rocky Ford. The canal is still in service, and does not appear to have suffered great diminution in its supply of water during the high-water stage of the river. The Settlers Ditch Company, which built the Settlers Canal at a first cost of approximately $35,000, was incorporated in 1874 with a capital stock of $10,000, in 50 shares of $200 each. These were held, at the time of the sale of the canal water rights, by about 50 persons.

All expenses of construction, repairs, maintenance, and management have been met by assessing the stockholders. Each share of stock entitles its holder to a proportional part of the water in the canal. Water is apportioned to each branch and to each distributing canal in proportion to the number of shares for which each draws water. No water is sold by the canal company, nor does the company lease any of the several shares which have reverted to it. Each stockholder, however, is permitted to lease his water to other persons, and can have it delivered to any point of the main canal or its branches which he selects. Water is delivered to irrigators through gates of various forms, generally under pressure. Its equitable distribution depends to a great extent on the judgment of the superintendent. Each share of water is supposed to be sufficient to irrigate 160 acres. The cost of water to the irrigators has averaged about 70 cents per acre per annum.

Lakeside Ditch.—This is another important diversion from the lower

portion of Cross Creek. The head of this canal is 4 miles below the head gate of the Settlers Canal, and 6 miles west from Goshen. The diversion from the natural creek channel is accomplished, as in the case of the Settlers Canal, by means of a weir or waste gate placed in the creek channel below the head of the canal, and a regulator or head gate in the latter about one-half mile below its head. The weir is a light timber structure arranged as a series of gates. It has a total width of 41 feet. Its nine openings between vertical posts are each 4 feet wide in the clear. The canal head gate has a width of 31 feet. The space between side walls is divided by vertical posts into six openings, each about 4½ feet wide in the clear. These openings or spaces between posts are closed with vertically sliding gates, to the stems of which power is applied by means of levers. The canal has a southwesterly course from its head for about 3 miles. In this distance it has a bed width of 30 feet and a fall of 6 inches to the mile. It can carry water about 3 feet deep. Its branches extend in southerly and southwesterly directions to the vicinity of Tulare Lake. The main canal and principal branches have an aggregate length of about 50 miles and command about 20,000 acres of land. The cultures on at least as much as one-half of this area may be considered to have been benefited by irrigation from this canal in a single season. The canal was constructed in 1874 and the years immediately following, at a total first cost of about $35,000.

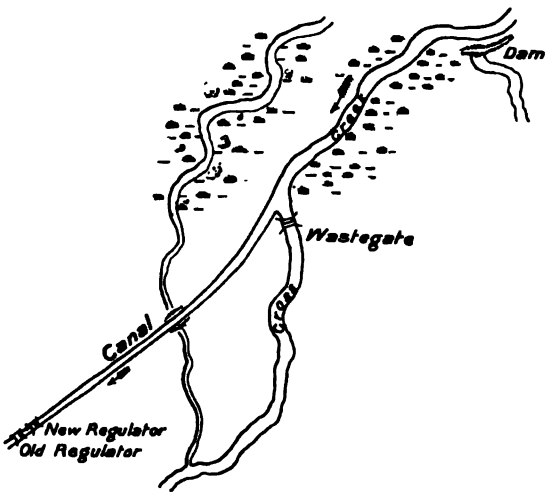


FIG. 3.—Head of Lakeside Ditch.

The canal is owned by the Lakeside Ditch Company, which was incorporated on August 7, 1874, with a capital stock of $10,000, divided into 10,000 shares of $1 each. On February 20, 1875, the capital stock was increased to 30,000 shares of $1 each. These shares were owned by ninety-five persons in 1885. Each share of stock entitles its holder to a proportional share of water in the canal. The canal company does not sell or rent water, not even on the few shares of stock held in the company's name. Each stockholder can have his water delivered at any point of any branch of the company's canal system. He can, if he desires, rent or sell his water for one or more

seasons. The company originally intended to deliver to each stockholder the water to which he was entitled at some point on his own land, but this system of delivery was found to be inexpedient and was abandoned in 1876. The distribution of water is in charge of a canal superintendent, who apportions the water to the various branches of the canal and has control of its delivery to the irrigator. The average annual cost of water from this canal has been about $1.55 per acre.

Jennings Ditch.—This is a small ditch which has its head on the south side of St. Johns River a little more than a quarter of a mile below the head of the Lower Wutchumna Ditch, and sends its branches into the northern portion of Visalia and adjacent territory. The main ditch has a bed width of 10 feet. The diversion of water is accomplished by means of a light wing dam of sand and brush, and the flow of water in the ditch is controlled by means of a simple regulator in the form of a box, 10 feet wide, which can be closed with loose flashboards. Water rights of an old date, preceding the formation of St. Johns River, are claimed for this ditch, whose head has been shifted back and forth between Mill Creek and St. Johns River.

Rodgers Ditch.—This is a small ditch, about 4 feet wide on the bottom, which supplies water to a few acres of land north and west of Visalia. It was constructed about 1875.

Modoc Canal.—This canal or ditch was originally intended to be made a distributary for the Wutchumna Canal water. It was constructed in 1876. Its head is on the south side of St. Johns River, just above the road leading northward from Visalia. Its length is about 4 miles, the course being a little south of west. Its bottom width is about 10 feet, and its capacity about 36 second-feet. Ownership in the ditch is represented by shares of stock. Water is distributed to stockholders in proportion to their interests. The annual expense of maintenance is about $100, which covers the construction of an inexpensive wing dam at the head of the ditch. The area actually irrigated is about 1,000 acres.

Hicks & Weston Ditch.—This is a very small ditch from the south side of St. Johns River, about 200 yards above the Modoc Canal. The ditch is 4 to 5 feet wide on the bottom. It was constructed in 1879. It receives water from the Wutchumna Canal in addition to its independent supply, and is sometimes called the Hicks Branch of Wutchumna Canal.

Hayes Upper Ditch (*Goshen Ditch*).—This ditch was constructed in 1881 or 1882 to supplement an older small ditch which was constructed in 1874 for the irrigation of lands near Goshen, theretofore considered almost worthless on account of the abundance of alkaline salts in the soil. The upper ditch has its head on the south side of St. Johns River about 4 miles northwest of Visalia. It has a westerly course and is about 4 miles long. Its dimensions are irregular. The pro-

moters of this enterprise constructed a small ditch and gave it an inexpensive, poorly protected head gate. The gate was carried off by the first freshet and the ditch was rapidly enlarged by erosion, so that it became a canal of considerable capacity. The second regulator put into its head was also a very light structure, 18 feet wide. Like many of the structures on Kaweah River, it was arranged as a box culvert, the entrance to which was divided into nine openings by vertical posts. The spaces between posts could be closed with loose flashboards. This ditch and the Lower Hayes Ditch both belong to the same owner, who has supplied some water to his neighbors at agreed rates per acre.

Hayes Lower Ditch.—The head of this ditch is about 1½ miles below the head of the Hayes Upper Ditch. Its course is a little south of west to the same region watered by the Hayes Upper Ditch. The ditch is about 4 miles long and 6 feet wide. Its head gate has a width of 10 feet. This ditch was constructed in 1874 by settlers near Goshen, but soon fell into the hands of the promoters of the Goshen Canal enterprise.

Pogues Upper Ditch.—This is the uppermost south-side diversion from Kaweah River. The head of the ditch is about 4 miles above the head of St. Johns River, a mile above the hill known as Limekiln Point. The ditch, which has a bed width of about 6 feet, skirts the northern and western base of Limekiln Point and commands several thousand acres of fine land lying between projecting spurs of the foothills. The ditch was constructed in 1884. Water is carried in a flume for some distance from the head of the ditch. This ditch now serves the citrus orchards at Lemon Cove, which have been set out within the last four or five years and now have an aggregate area of about 500 acres.

Pogues Lower Ditch.—This ditch was constructed in 1875. It diverts water from the south side of Kaweah River just below Limekiln Point. It has a southwesterly course, a bed width of 6 to 8 feet, and passes to the north and west of Wutchumna Hill, following the eastern border of the main valley and terminating at present at a point about 3 miles southeast of Exeter. Its total length is about 15 miles, and the capacity claimed for it is 30 second-feet. There was but little irrigation from this ditch at the time the second Pogue Ditch was constructed, but demand for water is rapidly increasing. The water is used on the lands set out to citrus fruits at and near Bonnie Brae. The area of citrus fruits now set out, all being dependent on this ditch for water, is 550 acres. Purchasers of land from the owners of this ditch are granted the right to call for water at the rate of 1 miner's inch (about one-fiftieth of a second-foot) to 5 acres. The charge of the water is 8 cents per inch per twenty-four hours. The lands (including the water rights) are sold at $75 per acre.

Ogden Ditch.—This ditch has its head on the south side of Kaweah River, about three-quarters of a mile below the head of Pogues Lower

Ditch. It has a southwesterly course, closely following the river, and terminates near Cottage. It is a very small ditch, about 4½ miles long, and supplies water to a few acres of alfalfa. It is said to be one of the old ditches, the date of its construction being given as 1862. The head of the ditch was not, however, always maintained at the same place, this having been impossible on account of the changes in the alignment and character of the river.

Hamilton Ditch.—This is another small private ditch on the south side of Kaweah River. Its head is about a mile above Cottage. It has a southwesterly course, is about 4 miles long, and about 4 feet wide. It has been in use since 1854. A south-side branch of the Hamilton Ditch is sometimes known as the Dillon Ditch.

Consolidated Peoples Ditch.—The difficulties experienced by irrigators

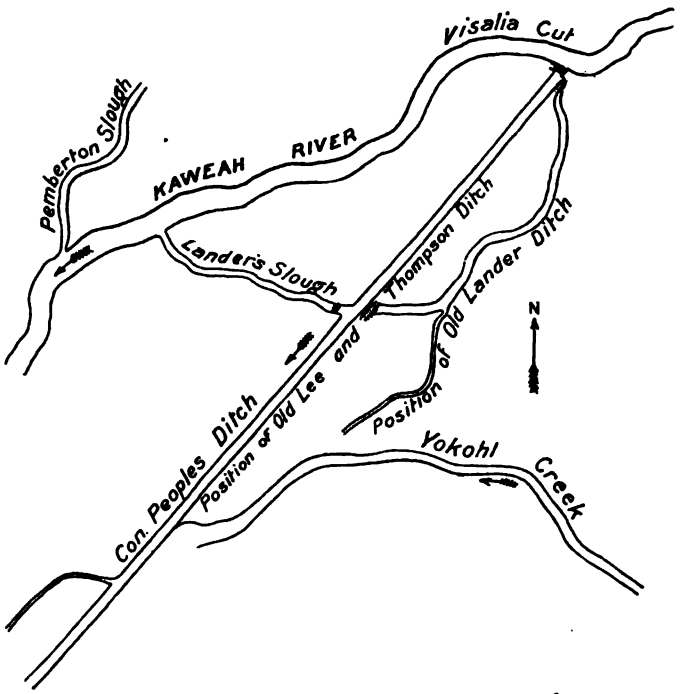


FIG. 4.—Head of Consolidated Peoples Ditch.

dependent for water upon the flow of Deep Creek, Packwood Creek, and Visalia Creek, after the freshets of 1861–62, led to a combination of interests, the direct result of which was the construction of the Peoples Ditch. The outlook for a sufficient supply of water was particularly bad after the winter of 1863–64, in which there was an unusual deficiency of precipitation, and, as a result of a conference with the owners of a number of small irrigation ditches, about one hundred interested persons assembled late in February, 1864, at the point where Landers Slough leaves the river and commenced work on the Peoples

Ditch, the water of which was to be apportioned to a number of ditches which before made independent diversions. The principal ditches that then became dependent upon the Peoples Ditch for water were the Landers, Lee & Thompson, Swanson, Turner, Grubbs, and Rice ditches. The expense of the canal construction was apportioned to the participating farmers according to relative interests. Most of them contributed labor, teams, and supplies. The ditch at its head was made 18 feet wide and 4 feet deep and was to have a fall of about 3½ feet to the mile. Work progressed rapidly and the ditch was considered finished by June 1, 1864. Its estimated cost at that time was $11,000. But owing to the obstructed condition of the old channel of Kaweah River below the head of St. Johns Channel, expectations as to flow of water were not fully realized, and upon petition the water commissioners of Tulare County granted the ditch company a franchise to remove obstructions from the old Kaweah River channel and to enlarge it where necessary to a width of 20 feet. Under the franchise work was done on the old river channel to a point near the present head of St. Johns River, about 4½ miles above the present head of the ditch. The river channel was thus kept open until again filled, in places, with drift and silt by the freshets of 1867–68. These freshets washed out the canal head gate in Landers Slough and considerably deepened and enlarged the upper section of the canal. During the period intervening between that winter and 1877, when the making of the Fowler Cut resulted in the practical reestablishment of the old channel of Kaweah River, water reached the head of the Peoples Ditch through a number of high-water channels leading in a southwesterly direction from the upper section of St. Johns River through Visalia Swamp. When water became scarce at the head of the canal, men would be sent up to St. Johns River to increase the flow toward the south by throwing obstructions into that river channel or by opening a better passage through the swamp. There has been a satisfactory supply of water to the head of the Peoples Ditch ever since the Fowler Cut was made.

This cut was made by Mr. Samuel Fowler under contract with the Kaweah Canal and Irrigation Company, which had entered into an agreement with the management of the Peoples Ditch concerning the apportionment of water. The agreement, which was formally executed on December 21, 1878, but subsequently set aside by a decision of the courts, provided for a joint ownership of the upper portion of the Peoples Ditch and of the water way above the head of that ditch as improved by the Kaweah Canal and Irrigation Company, and conceded to the Peoples Ditch the right at all times to as much water as will flow in a ditch 50 feet wide and 2 feet deep on a grade of 6 inches to the mile. The water of Kaweah River which passes the head of St. Johns Channel separates into two channels, each about a mile long, forming an island about 11 miles above Visalia. The upper portion of the

northernmost of these channels is known as the Hamilton or Visalia Cut. The southernmost is Lander Slough, or the enlarged channel of the Lander Ditch. It is the upper portion of Lander Slough which until 1896 carried water to the point where the flow was brought under final control for the Peoples Ditch. But when the canal regulator failed Landers Slough was closed near its head and an artificial canal was substituted for the Landers Slough section of the Peoples Ditch. A box inlet 20 feet wide and 10 feet deep is maintained in the head of this new canal section, which structure seems to be intended more as a partitioner of the flow of Kaweah River than as a regulating gate in the ordinary sense.

The Consolidated Peoples Ditch has a southwesterly course from Landers Slough for 3 miles to the point where its water was separated from that of the Kaweah Canal, so long as that canal was in service. The main canal extends from that point about 1½ miles farther, to a point known as Dillons Mill, where some of its water is in use to supply power. The section of the canal next below Landers Slough follows the original alignment of the Swanson Ditch for about three-fourths of a mile, following and finally crossing the almost obliterated channel of Yokohl Creek. The occasional flow of this creek is admitted into the canal, and surplus waters are discharged through a waste gate into Outside Creek, which was originally a continuation of the Yokohl Creek channel. The main canal is of somewhat irregular dimensions, much of it having the appearance of a natural channel. Its width is generally 30 to 50 feet and its capacity probably exceeds 400 second-feet.

The consolidation of the interests of the several small ditches and individual irrigators, as already explained, led finally to an incorporation of their organization. This was effected in 1874, and the corporation received the name of the Consolidated Peoples Ditch Company. Its capital stock was fixed at $9,700, in 97 shares of $100 each. Canal expenses are assessed upon stockholders. No water is sold by the canal company. At the time of constructing the canal it was agreed that each person interested in the main canal should contribute toward construction down to the point at which his water was to be delivered into a branch ditch. All branch ditches are under independent management. Water is distributed to the various branch ditches, under the direction of the president of the company, in proportion to the number of shares of stock for which water is to be delivered to each. The apportionment of water between the main canal and a branch ditch is accomplished by constructing a sill or floor at the same elevation in each, the effective width of canal and ditch on each sill being made proportional to the amount of water to be passed. The cost of constructing and maintaining these structures falls upon the canal company. The area of land actually irrigated in a single season with water from the Peoples Ditch has exceeded 5,000 acres. The total expendi-

ture on the main canal chargeable to the construction account has been about $50,000.

Swanson Ditch.—This is a branch of the Peoples Ditch, receiving its water about three-quarters of a mile below the point where the latter leaves Landers Slough. It has a southwesterly course and is about 4 miles long. It is reported to have been in use as an independent ditch as early as 1855. While the supply of water from the Peoples Ditch was somewhat unreliable—preceding 1878—irrigators dependent upon the Swanson Ditch endeavored to keep the head of Packwood Creek open, but with indifferent success. Since that time the ditch is to be regarded merely as a branch of the Peoples Ditch.

Lee & Thompson Ditch.—This was a second old ditch, almost parallel with the Swanson for some distance. Its alignment was adopted for the Peoples Ditch for a considerable distance, and only the lower end of the original ditch remains in use as a small distributary of the Peoples Ditch water.

Rice Ditch.—This is another small ditch, now a branch of the Peoples Ditch, which was in use before the latter was constructed. Its course is southerly from a point near the lower end of the main ditch. It is about 6 miles long, terminating in a branch of Outside Creek used as a distributary of the Peoples Ditch water under the name of the Bliss & Hyde Ditch, and it commands a narrow strip of land lying to the east of Outside Creek.

Catron and Teague ditches.—These are two small branches of the Peoples Ditch, both of which receive water from the south side of the latter through a common head about 2 miles below Landers Slough. Their course is southerly. The former is about 3 miles long, the latter about 4, and both are connected at their lower ends with the Rice Ditch, into which surplus water is dropped.

Bliss & Hyde Ditch.—This is a branch of the Peoples Ditch, receiving its water a quarter of a mile below the head of the Catron and the Teague ditches. At that point a short cut from the south side of the Peoples Ditch drops water for this branch into a natural channel—the eastern branch of Outside Creek—which is the same channel used above that point as a common head for the Catron and the Teague ditches. This channel has a course a little west of south for about 12 miles, to the point where the water of the branch ditch is used, about 6 miles east of Tulare, on both sides of Outside Creek, there known in part as Elk Bayou. Water is diverted from Outside Creek into two irrigation ditches, one upon either side, each of which has a length of about 2 miles.

Davis, Brown, and Pennebaker ditches.—These are three short branches of the Peoples Ditch, all receiving water from it at or near the termination of the main canal, and supplying water to lands near Farmersville.

Extension Ditch.—After the use of a portion of the water of the

Peoples Ditch for power at Dillons Mill, which is at the termination of the main canal, it flows into Outside Creek. The creek channel is closed with an overfall dam of brush, which serves as a waste way for all water not required for the Extension Ditch. This ditch is one of the principal branches of the Peoples Ditch. It has a southwesterly course, and, with its branches, commands the region to the west and northward of Farmersville. It was built by the farmers whose lands it waters. They have formed a corporation known as the Extension Ditch Company, whose shares of stock are in the hands of thirty or more irrigators. The affairs of this company are managed entirely independent of the Peoples Ditch Company, which merely delivers to it the water which its stockholders are entitled to receive from the Peoples Ditch.

Kaweah Canal.—The enumeration of this canal is merely historical.

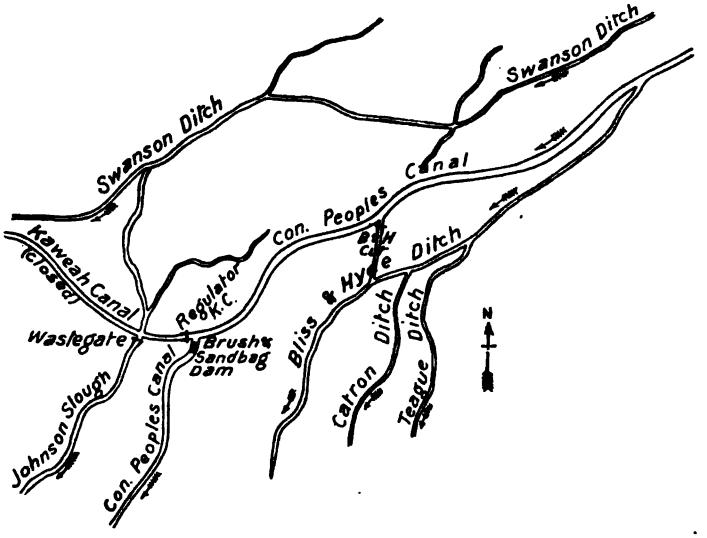


FIG. 5.—Ditch system at head of Kaweah Canal.

It is one of the canals whose successful operation was greatly interfered with by litigation. The canal was constructed in 1877. At that time the Fowler Cut was made for the Kaweah Canal and Irrigation Company, and led to the reestablishment of the original channel of Kaweah River, or of a new channel very nearly coincident with the original one in position. The agreement then made with the Consolidated Peoples Ditch Company gave the new company a right to use the upper sections of the Peoples Ditch for several miles, and below that point a canal was excavated, about 50 feet wide on the bottom and 3 feet deep, which temporarily dropped its water into Deep Creek, in which it flowed to within a few miles of Tulare. The main canal was soon afterwards extended across Deep Creek in a general southwesterly direc-

tion, passing about a mile to the west of Farmersville, until, at a point about 6 miles to the northeast of Tulare, it was separated into two main branches, of which the southerly one commanded the lands in the vicinity of Tulare, including the colony lands toward the west. The northerly branch was extended westerly across Cameron Creek to a connection with the Tulare Canal, and has irrigated a few tracts of land near Tagus. The total length of the main canal, not including the Fowler Cut or the Peoples Ditch, to where it separates into its two principal branches is about 10 miles. Irrigation from this canal has probably exceeded 4,000 acres. The canal was constructed by a corporation known as the Kaweah Canal and Irrigation Company, which was organized in 1877 by farmers who were in need of water for their lands in the vicinity of Tulare. The capital stock was fixed at $50,000, in 500 shares. The expense of canal construction and litigation soon exceeded this sum by at least $10,000. The canal always held its water for sale, but stockholders were entitled to receive it at slightly reduced rates. All expenses in excess of revenue derived from the sale of water were apportioned to stockholders. Water was not sold by measurement; it was delivered to the irrigators from the several canal branches in rotation, and was paid for at fixed rates per acre actually irrigated, generally $1 to $2 per acre. The right of the canal to receive any surplus waters from the Peoples Ditch was disputed in court by farmers who, as riparian owners on Outside Creek, demanded that all flow in the Peoples Ditch in excess of that required for that ditch should be wasted into channels leading into Outside Creek. Their claim having been sustained, the Kaweah Canal for many years received water only by sufferance and only during periods when the river afforded an abundant supply. Its water was no longer taken through the head of the Peoples Ditch, but a cut was made from Kaweah River below Deep Creek to the canal, and the upper half mile of Deep Creek itself was utilized as a source of supply. After the organization of the Tulare irrigation district the canal was sold to the district for $150,000, payment being made in bonds, but with the proviso that the stockholders of the Keweah Canal and Irrigation Company should be preferred takers of one-third of all the water entering the upper section of the canal, at the agreed price of $1.25 per acre per annum.

Farmers Canal.—This canal has its head on the east side of Deep Creek, about 2 miles below Farmersville. It has a southwesterly course, commanding several thousand acres of land between Elk Bayou and Deep Creek channels within 6 miles of the head of the canal. The bed width of the canal for several miles below its head is 14 feet. The head gate or regulator has a width of 18 feet. The water is turned from the creek into the head of the canal by means of a brush dam. The canal was constructed in 1875 by an incorporated company, whose members are the farmers using canal water. The capital stock was

fixed at $20,000, in shares of $100 each. The head of Deep Creek, from which diversion is made for this canal, is about 8 miles, in a direct line, above Visalia, on the south side of Kaweah River. No water flows into Deep Creek from the river during its low stages. Water is generally available from the beginning of March to the end of June. During this time a superintendent is employed to apportion the water to holders of stock. When the supply of water is limited it is used in turn by the irrigators. Each stockholder is permitted to sell or lease the water to which he is entitled. The water represented by a few shares of stock held in the name of the corporation itself is also subject to sale. The estimated cost of canal construction and expenses connected therewith is about $7,000 to $8,000. The annual assessment per share of stock for canal management and maintenance has been about $1. The structures necessary for a delivery of water into branch ditches are constructed and maintained at the expense of those who receive water through each.

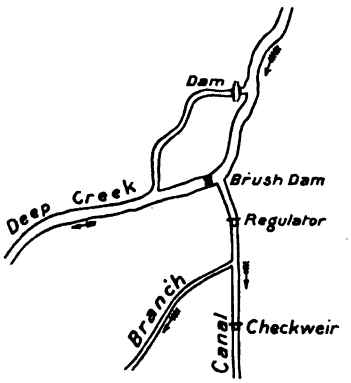
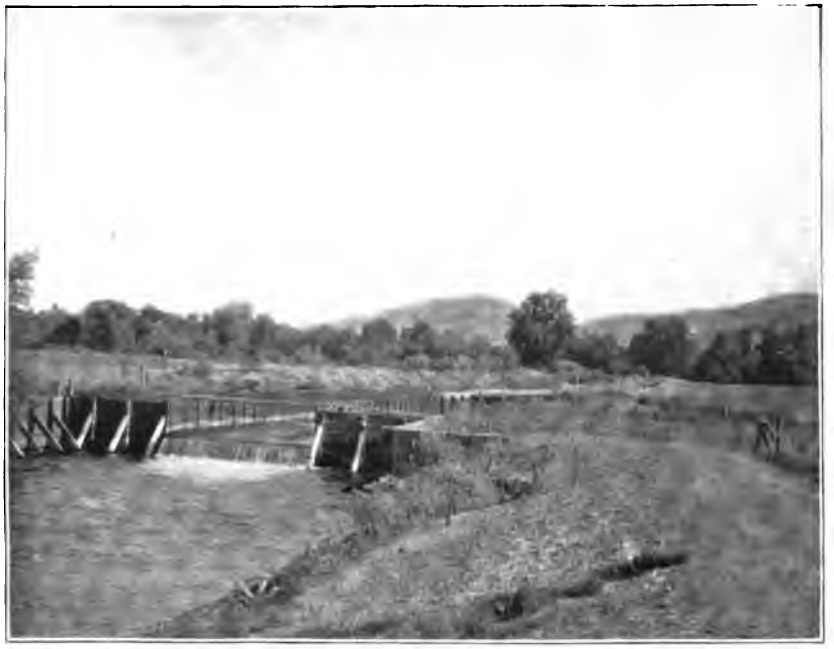


FIG. 6.—Head of Farmers Canal.

Tulare Canal.—This canal was constructed for the irrigation of lands in the vicinity of Tagus and to the northwest of Tulare. Its head is on the south side of Kaweah River, about midway between the head of Deep Creek and the head of Packwood Creek. It has a southwesterly course, is about 15 miles long, and has a bed width of 16 feet. The canal passes about 2½ miles to the south of Visalia and a mile to the south of Tagus, and terminates at the main canal of the Rocky Ford Canal Company. The canal was constructed in 1873. The farmers interested in the enterprise formed a corporation in the following year, known as the Tulare Irrigating Company, whose capital stock was fixed at $40,000, in shares of $100 each. The diversion of water from the river is accomplished by means of a dam or weir of brush, and the inflow into the canal is controlled by a regulator or head gate 16 feet wide. It has been claimed that the Ketchum Cut, one of the several ditches from St. Johns River southwesterly to Kaweah River above the head of the Tulare Canal, has been utilized by the Tulare Irrigating Company to accomplish the diversion of its water direct from St. Johns River, but it has not been possible to verify this claim, or to ascertain whether the canal company has any proprietary interest in the Ketchum Cut.

Before 1885 it was customary to apportion the flow of the canal to the stockholders in the corporation in proportion to their respective interests, but the holders of stock who were not ready to make profitable



A. FLUME OVER TULARE CANAL, THE MAIN CANAL OF TULARE IRRIGATION DISTRICT.

B. MAIN CANAL OF TULARE IRRIGATION DISTRICT.

use of their water demanded a change, and it was at that time decided to permit each stockholder to irrigate free of cost as many acres as he held shares of stock, and to charge $1 per acre for all additional areas.

Rocky Ford Ditch.—This ditch, now a part of the Tulare irrigation district canal system, takes its name from Rocky Ford on St. Johns River, because half a mile above is the head of the Ketchum Cut, which was bought by the Rocky Ford Canal and Irrigation Company, and was supposed to deliver water for the canal from St. Johns River into the Kaweah, from which it was reclaimed for the Rocky Ford Ditch at the head of Packwood Creek. The head of Packwood Creek, which had been almost obliterated by the freshets of 1861–62 and 1867–68, was reopened by this canal company in 1876. A cut 9 feet wide and three-quarters of a mile long, following the channel of Packwood Creek, received the canal water from Kaweah River. The water thus diverted was carried southwesterly in Packwood Creek, and in its south fork about 2½ miles, thence south in a ditch three-quarters of a mile to another natural channel, from which, a half mile below, it was dropped into Cameron Creek, which it followed, still in a general southwesterly direction, to a point about a mile south of Tagus. At that point the water was taken into a system of distributing ditches covering 4,000 to 5,000 acres of land to the southwest of Tagus, between Cameron and Packwood creeks. About $20,000 was expended on this work, besides $3,000 in litigation, but after a few years the company was deprived of the use of the Packwood Creek channel by an order of court, and those dependent upon this canal found themselves without water.

Cameron Creek Company.—This was an unincorporated organization of farmers which may be considered an offspring of the Rocky Ford Ditch Company. The purpose of the organization was to secure water for the Rocky Ford Canal, the head works of which were thrown out of service by orders of the court. There was ordinarily a surplus flow of water in the spring months, which reached Cameron Creek by way of the Deep Creek channels and the Kaweah and Tulare canals. The water thus reaching the Rocky Ford Canal from Cameron Creek was distributed to irrigators under the management and control of the Cameron Creek Company. The owners or lessees of stock in the Rocky Ford Canal Company were the preferred purchasers of water, but if there was sufficient available it was also sold to farmers who held no stock. The apportionment of water was by rotation in the use of the flow of distributaries. The time of use per share of stock was reduced as the supply decreased. The charge for water was at the rate of $1 per year per acre irrigated. The necessity for operations by this company ceased upon the completion of the canal system of the Tulare irrigation district.

Bacon & Crossmore Canal (*Packwood Creek Canal*).—When, in 1875, it became necessary to improve the flow of Packwood Creek for the supply of water to a large tract of land 6 to 9 miles west from Tulare,

a ditch was constructed from St. Johns River, then the principal channel of Kaweah River, commencing about a hundred yards above Rocky Ford, thence southwesterly about 4 miles, passing to the north and westward of a group of low hills known as the Swamp Angels, to a connection with the old channel of Kaweah River. Water thus turned into this channel was allowed to flow to a point in Visalia Creek about 1¼ miles below the head of Packwood Creek and was there diverted into a canal about 1,000 feet long leading southerly into Packwood Creek. These two ditches, or canals, together with the natural channel of Packwood Creek, are known as the Bacon & Crossmore Canal. The upper portion of this canal has a width of about 16 feet. The width of its head gate or regulator at St. Johns River is 40 feet. The cut for Visalia Creek into Packwood is about 30 feet wide. Its flow is controlled by a gate 30 feet in width. The point of discharge of the canal from St. Johns River into the Kaweah is just below Goads Dam at the head of the Tulare Canal. To enable diversion of water from Visalia Creek into the channel of Packwood Creek by way of the Bacon & Crossmore Cut, a brush dam is maintained in the creek about 60 feet below the head of the cut. The flow of Packwook Creek as thus established is first checked at a point about 4 miles west of Tagus, where distributaries are in use upon either side of the creek channel. Several other diversions are made some miles farther down the creek, and it is claimed that several thousand acres of land are irrigated by this ditch system.

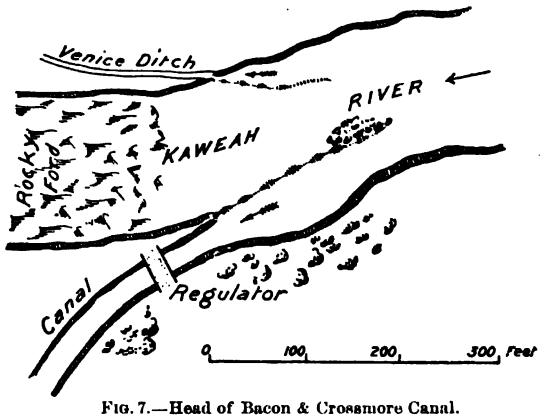


FIG. 7.—Head of Bacon & Crossmore Canal.

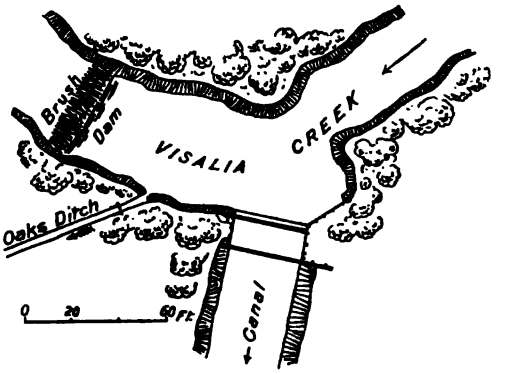


FIG. 8.—Head of Bacon & Crossmore Cut.

Judd Ditch.—This ditch was in use but a short time subsequent to the freshets of 1867–68. An organization of interested farmers known

as the Judd Ditch Company at that time endeavored to keep the head of Packwood Creek open, but owing to controversies with people living near Visalia on Visalia Creek the attempt was soon abandoned.

Cutler & Higgins Ditch (Chatten Ditch).—This is a small ditch between St. Johns River and Visalia Creek. Its head is on the north side of Kaweah River just above the point where it divides into the two channels, Visalia Creek and Packwood Creek. It has a westerly course, is about 2 miles long, 3 to 6 feet wide on the bottom, and belongs to several farmers, who take turns in using its water for the irrigation of a few hundred acres of alfalfa. The ditch has been in use since 1857.

Kaweah and Mill Creek Water Company.—This corporation was organized in 1877 with a capital stock of $10,000, in 200 shares, for the purpose of harmonizing and protecting conflicting interests by maintaining and controlling the flow of water in Mill Creek (Visalia Creek) and distributing it to the canals and ditches entitled to receive it. Its shares of stock were distributed to the owners of the various canals and ditches according to their relative interests, and the superintendent of this company is required to apportion the amount of water available to each ditch and canal in proportion to the number of shares of stock for which water is to be turned into each. A decision of the courts favoring the riparian doctrine has, however, made it difficult for ditch owners along Mill Creek below Visalia to reclaim their water, as the decision interferes with the construction of dams in the creek channel so long as they are objected to by riparian proprietors. To increase the flow of water in Visalia Creek it was found necessary to open the head of Lane Slough. This had been done before, but later freshets had again obstructed its channel near St. Johns River. The Bostwick Cut was the result of the work done by the company at that point. This is a canal leading southerly from St. Johns River, about a mile above Rocky Ford, into the main channel of Lane Slough. Lane Slough was one of the several natural channels having a southwesterly course through Visalia Swamp from near its northern margin to the old channel of Kaweah River above the head of Visalia Creek. It is claimed that this slough was so obstructed with drift and silt by the freshets of 1861–62 that for reclamation purposes it was necessary once before to open it, under direction of State authorities, with moneys from the swamp-land fund. The water company in 1878 also caused a section of the old channel of Kaweah River just below the head of Landers Slough to be reopened. The work there done resulted in the formation of the Hamilton Cut. All expenses of management incurred by the Kaweah and Mill Creek Water Company are raised by assessments levied upon the stock. The principal ditches dependent upon this organization for their water supply are the Oaks, Watson, Burch, Mill, Bahwell, and Fulgham ditches.

Oaks Ditch.—The head of the Oaks Ditch is on the south side of Visalia Creek, just above the dam maintained below the head of the Bacon & Crossmore Cut. It was in use prior to the organization of

the Kaweah and Mill Creek Water Company, from which it now receives its water. It is a small ditch, flowing several miles westerly between Visalia and Packwood creeks, and supplies water to seven or eight small farms. The entire flow of the ditch is usually divided into two irrigating heads.

Evans Ditch.—This ditch, which has also become dependent on the Kaweah and Mill Creek Water Company for its supply of water, has its head on the south side of Visalia Creek about 2 miles above Visalia. Its upper section serves as a common head for three otherwise independent ditches, the other two being the Burch and the Watson ditches. The Evans Ditch is entitled to one-half of the water entering its head, the Watson to one-third, and the Burch to one-sixth. The ditch has a southwesterly course, is about 5 miles long, and supplies water to about 500 acres just to the south of Visalia. Ownership in the ditch is represented by shares of stock, and the distribution of water is made in proportion to the number of shares of stock owned or controlled by each irrigator. Water is generally available for ten months each year, and is used in turn by the irrigators.

Evans & Turner Ditch.—This is a diversion from the west side of Packwood Creek about 2 miles below the Bacon & Crossmore Cut. It has a westerly course, is about a mile long, and drops its water into the Evans Ditch. It is claimed that this ditch was in use as early as 1858, but if so it was out of service for many years preceding its reestablishment, about 1884.

Burch Ditch.—This is another small ditch to which water is supplied under control of the Kaweah and Mill Creek Water Company. Although the ditch was in use before the organization of that company, and then received water direct from Visalia Creek, it has of late years been supplied with water through the head of the Evans Ditch. Its water, together with that for Watson Ditch, is turned out of the west side of Evans Ditch one-half mile below its head. It flows westerly three-quarters of a mile in a channel used in common with the Watson Ditch, and thence a little south of west to the southwestern portion of Visalia. It supplies a number of small farms southeast of Visalia. The head of the ditch was originally on the north side of the creek and its water was brought to the south side in a flume.

Watson Ditch.—This is another of the old irrigation ditches in whose interest the Kaweah and Mill Creek Water Company was organized. This ditch was constructed in 1854, before water was used by the mill in Visalia. Its head was on the south side of the creek about 3 miles east of Visalia, and its water was used near Visalia. It now receives water through a common head with the Evans and the Burch ditches, and is finally separated from the Burch Ditch water about a mile east of Visalia. Ownership in this ditch is represented by shares of stock, of which 100 may be issued. Between 60 and 70 are in the hands of fifteen to twenty farmers, who use its water mostly on small farms to the south and southwest of Visalia. It was originally intended that

each share of stock should represent 17.28 miner's inches of water (about one-third second-foot), and the original price per share was fixed at $5. Stockholders are assessed for all expenses of management and repairs. A superintendent is employed only when necessary, not when water is abundant, nor when there is none at all. Shares of stock not issued are not entitled to water. Holders of stock may sell or lease the water to which they are entitled. When the flow of the ditch is small it is given to the irrigators in turn for eight hours per share of stock. The annual expense of ditch management is about $5 per share.

Mill Ditch.—This is not an irrigation ditch, but it has rights to the use of water from Kaweah River, which make its enumeration among the Kaweah River ditches desirable. Its head is about one-half mile above Visalia, on the south side of Visalia Creek. It has a westerly course into the town, and drops its water back into the creek at the mill. It has been in use since 1854, at which time a brush dam was constructed at its head in Visalia Creek. This is another of the ditches in whose interest the Kaweah and Mill Creek Water Company was organized. The mill owners are stockholders in this corporation and receive the same consideration accorded to irrigators.

Bahwell and Fulgham ditches.—These are two small ditches below Visalia, which were included among those for whose benefit the Kaweah and Mill Creek Water Company was formed. They and a number of other small ditches make use of the freshet flow of Visalia Creek reaching the lower sections of Mill Creek, as well as of the water which is returned to the creek by the Mill Ditch.

Longs Canal.—This exists in name only. It was a canal or reopened slough constructed, some years after the freshets of 1861–62, southwesterly through the upper end of Visalia Swamp, from St. Johns River to Potter Slough, which discharged into Kaweah River. The first work done there was nominally for reclamation purposes—to facilitate drainage of the swamp. The canal was closed by the drift and silt brought down by the freshets of 1867–68, and was again opened at the expense of the Kaweah and Mill Creek Water Company.

Bostwick Cut.—This is a short ditch or canal, southwesterly from St. Johns River about three-quarters of a mile above Rocky Ford, to Lane Slough, which continues in a southwesterly direction to Kaweah River. It was constructed in 1863 or 1864, for drainage purposes, with money from the swamp-land funds. There seems to be no doubt, however, that it would not have been constructed had it not been desirable to increase the flow in Visalia and Packwood creeks for irrigation purposes. The cut was filled with drift and silt by subsequent freshets, and was again opened in 1876 by the same parties who the following year organized the Kaweah and Mill Creek Water Company. It is about 18 to 20 feet wide on the bottom and half a mile long. It is provided with a head gate having a width of 22 feet.

Ketchum Cut.—This is a ditch, about 8 feet wide on the bottom, having its head on the south side of St. Johns River about a half mile above Rocky Ford. Its course is thence southwesterly, skirting the eastern base of the Swamp Angels to Kaweah River, one-half mile above the head of the Tulare Canal. The ditch was constructed, probably about 1864, with money from the State swamp-land funds, ostensibly for drainage purposes. It was originally carried across Kaweah River. The right to use it for irrigation purposes has been claimed by the Rocky Ford Canal Company, and, possibly, also by the Tulare Irrigation Company. It seems to have been in use principally for the irrigation of a few small tracts of land on the north side of Kaweah River. Its flow is controlled by a head gate.

Crowley & Mehrtens Ditch.—To make the enumeration of the old irrigation works complete it is necessary to mention the Crowley & Mehrtens Ditch, which was a small ditch in use for some years on the south side of Kaweah River, westward from Wutchumna Hill. The head of the ditch was near the northwestern base of this hill. There is nothing left of it now except an old cut in rotten granite on the south bank of the river, just below where St. Johns River leaves the Kaweah.

TULARE IRRIGATION DISTRICT.

This district was organized in September, 1889, by landowners in the vicinity of Tulare. Those dependent upon the Rocky Ford Canal and Cameron Creek for their irrigation water seem to have been the prime movers in the matter of district organization. The lands dependent upon Packwood Creek (Bacon & Crossmore Canal) and upon the Kaweah Canal were mostly excluded from the district. The district has an area of 39,200 acres, including the 2,500 acres in the town site of Tulare. After much preliminary work, involving the examination and surveying of a number of feasible canal routes and reservoir sites for water storage, it was decided to purchase the water rights of the Settlers Ditch. This was done for $100,000, in district bonds, through an agent, who at the same time agreed to take an additional block of district bonds amounting to $50,000. The money realized from this bond sale was expended in constructing a canal, 60 feet wide on the bottom, from a point on the north side of St. Johns River about one-half mile below Rocky Ford in a southwesterly direction, nearly parallel with the river, about 2½ miles, to the southern base of Iron Mountain, where the canal water is carried across St. Johns River in a flume 9 feet wide and 4½ feet deep, which is supported by two bridge spans. The course of the canal from St. Johns River is a little west of south to Kaweah River, which is crossed in a similar flume. It then has a course due south to a junction with the Kaweah Canal. Before this entire canal section was completed the available $45,000 had been expended and the district was still without water. The Kaweah and Rocky Ford canals were purchased for $20,000. Contracts were let for the construction of

A. CANAL REGULATOR AT KAWEAH RIVER, TULARE IRRIGATION DISTRICT.

B. LATERAL, ONE MILE SOUTH OF TULARE.

lateral canals and for the enlargement and completion of the main canal, work being practically paid for in bonds which, it was understood, went to the contractor through a nominal purchaser. Main distributaries were carried through the district from northeast to southwest, and smaller ones, generally on land lines from north to south, completed the canal system. The aggregate length of district canals is said to exceed 150 miles, and the main canal capacity is given at 800 second-feet. It should also be said that the completed system of works involves the construction of a storage reservoir at Iron Mountain, to be supplied with water by means of a high-line canal with head somewhere near Dillons Point. The reservoir site has in part been purchased. The total bond issue by the district was $500,000, all of which has been disposed of.

The area of land irrigated in the district has been rapidly extended. It is said that from 5,500 to 30,000 acres, principally in alfalfa, cereals, and orchard, have actually been irrigated, the area varying within wide limits, according to amount and duration of the water supply. The inflow of water to the canal is controlled by means of three head gates or regulators, of which the one on the north side of St. Johns River is 60 feet wide, and each of the others 25 feet. They are all of the loose flashboard type, the several openings being about 4 feet, and the drop boards being supported by inclined timbers. A canal superintendent has general charge of water distribution, and he is assisted by ditch tenders. Water is generally available during the four months April to June, inclusive. Operating expenses are met by charging for water, the charge being fixed at 50 cents to $1 per acre for the first irrigation and half price for subsequent wettings. The charge in 1897 was 50 and 25 cents. The tax to meet interest on bonds and cost of its collection has been 1.85 to 1.90 per cent.

WATER SUPPLY, SOILS, AND METHODS OF IRRIGATION.

Prior to the great changes in channel alignment effected by the freshets of 1861–62, the Kaweah River waters spread at high stages over what was known as Visalia Swamp, which commenced at Wutchumna Hill and extended southwesterly about 9 miles, with a width of 1 to 3 miles. The spreading waters were reunited in various channels, as already explained, in and below this swamp. Channel capacity was inadequate to pass flood waters, not only in the swamp, but also below it. It was inexpensive to divert water from a natural channel, or even from a convenient spot in the swamp, into ditches, and the use of water for irrigation commenced soon after the arrival of the first settlers. A number of ditches were thus in use when the regimen of the river was changed by the freshets above mentioned, and entirely new works became necessary in some cases to keep the ditches supplied with water. It was some time before the magnitude of the changes in the river alignment and their ultimate effects were fully realized, and final

relief to those dependent upon the more southerly channels for water did not come until the old channel of Kaweah River was reopened as the Fowler Cut in 1877. Meanwhile there had been a continually increasing demand upon the several river channels for water, and almost every season at the close of the river's high stage there was contention and strife concerning the apportionment of the low-water flow to the different sections of Kaweah delta. Farmers who had settled on Canoe Creek, Elbow Creek, and Cross Creek had become accustomed to regard St. Johns Channel as the principal arm of the river, and dams for its diversion southward into and across Visalia Swamp were not tolerated without protest. When the low-water flow was finally restored to the old channel numerous attempts were made to force it back into St. Johns River, and amicable adjustment seemed out of the question. To avoid the possibility of having a permanent change made at the head of St. Johns River, land was there acquired by the principal south-side ditch companies. A brush dam was then tolerated in the Kaweah River channel, which effected a division of the flow at comparatively low stages, but the exact basis of water apportionment, if any had ever been agreed upon, is not known to the writer. After many years of individual effort some of the settlers were forced into cooperative measures, as already explained, with some degree of success. Had there been greater obstacles to overcome in securing control of water in the first instance, the development of irrigation might have been less rapid, but would probably have been ultimately effected with less friction.

The ditches and canals constructed for the reclamation of Visalia Swamp, as already referred to, were hardly necessary as drain ways, because the increased capacity given the river channels by the freshets of 1861–62 had greatly improved drainage, and they have in a measure become features of the irrigation system of this river.

The surface of the country watered by the many delta channels of Kaweah River has a slope from east to west of about 6 to 7 feet to the mile. The portion of it near Visalia and thence southwest to Tulare, which is generally known as the Four Creek country, is covered, in some places very densely, with a growth of majestic oaks. The soil in the upper portion of Visalia delta is a rich alluvial loam, generally sandy, sometimes heavy. Near the river the soil is deep, resting on sands or gravel. At the base of and between the outlying hills on each side of the river the predominating soil variety is a black loam or dry bog, containing much clay, sometimes gravel, and merges into the heavy red soil of the upper or eastern border of the valley plain. Under the soil of this plain a hardpan layer several feet thick is nearly everywhere found at depths of from 1 to 5 feet. Northward from Kaweah River this valley plain extends in a broad belt along the foothill base. The soil of this belt is of the usual heavy red variety, containing some gravel. Its surface is very generally besprinkled with the low mounds usually known in the West as hog-wallows. The ground water

of this north-side district is from 8 to 30 feet below the surface, depth increasing northward from the river and eastward toward the foothills. Westward from this high east-side plain, and still northward from the river-delta lands, the soil becomes shallower and alkaline salts abound in its surface layers. In the Mill Creek country, 4 or 5 miles westward from Visalia, the hardpan of the higher plain disappears, but the alkaline salts remain present in undesirable quantity.

The soils of the entire delta are generally sandy loams, chocolate colored, deep and strong, without the sublayers of hardpan that are characteristic of the plains. Ground water in the Kaweah (or Visalia) delta is usually at 8 to 12 feet below the surface. Near Tulare and westward from that town the soil is darker than in other portions of the delta. The surface of the soil throughout the delta is smooth and entirely free from the hog-wallows of the adjacent main valley uplands.

Intermediate between the Sierra Nevada foothills and Outside Creek, and southward from Kaweah River, is another belt of country, 3 to 10 miles wide, extending far southward toward Tule River and embracing many acres of excellent, rather heavy soil.

The light average annual rainfall in the Kaweah delta, only about 9 inches, the abundance of natural water courses, and the ease with which water can be diverted into ditches and kept under control, are circumstances which have combined to stimulate ditch and canal construction in this section of the State, but not for speculative purposes. The irrigation works are almost all owned by the farmers who need the water. There are but few irrigators who do not own stock in some ditch company. All irrigation canals in the delta have been carried in the most direct lines from source of water to place of use. They are almost invariably located on lines parallel with the main drainage lines of the country.

The lands watered by Kaweah River are utilized for diversified farming. The natural growth of trees and grasses has always been luxuriant to the limit of the overflow from the delta channels, and the construction of canals and ditches has greatly increased the wet area. Large areas are in use as natural pastures, particularly to the east and north of Visalia. Wheat still remains the staple farm product, but considerable areas have been planted to alfalfa, while the orchard and vineyard and the occasional truck patch give evidence of the rapid movement toward a more intense cultivation of the soil.

The aggregate capacity of the canals, ditches, and water courses whose flow is under the control of ditch companies will probably exceed 2,000 second-feet. There are fortunately many years in which for months at a time, and just when water is most needed, the flow of the river is in excess of this amount. It is difficult to approximate the area irrigated or benefited with water from Kaweah River, because in many instances water is not actually applied to the surface of the land, but reaches the soil indirectly through seepage. There is no way of collecting even imperfect statistics, however, except at great labor in

the field, so that when it is stated that about 50,000 acres are actually irrigated and an additional 40,000 acres are more or less directly benefited with water from this river, too great reliance should not be placed upon the statement.

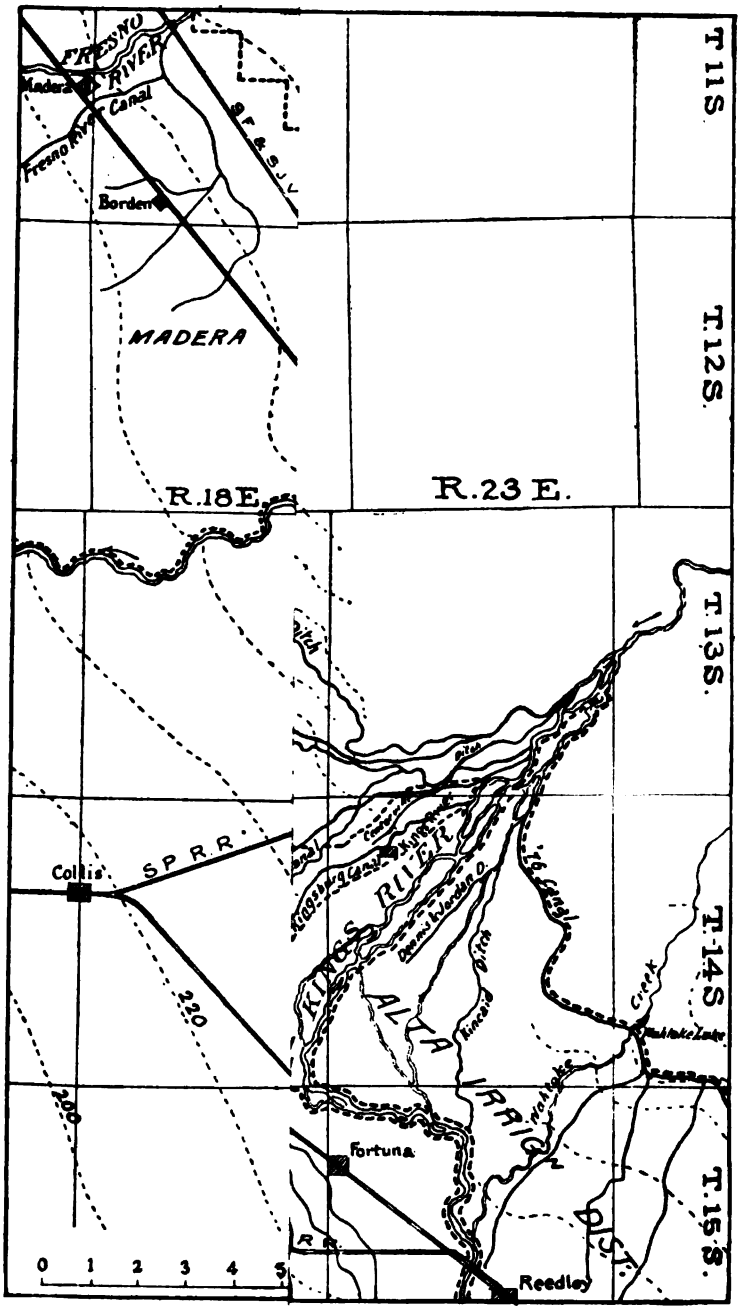
There are very few structures of any kind in the main canals, and but few are required to regulate the grade. Erosion is not undesirable, as the canals are generally long and water is taken from each at comparatively few points; hence the increased cost of providing weirs at points where water is to be diverted is more than offset by the increased capacity resulting from erosion.

All structures for the diversion of water, except dams at the heads of canals, are timber structures; none are of brick or stone. Dams across natural water courses are generally constructed of brush or gravel, and require some annual repairs. No extended observations have been made in this section to determine the loss of water from canals in transit to the lands irrigated; and it is to be remembered in this connection that not all water sinking into the ground from natural or artificial water courses is considered lost, because it is this very loss which fixes the elevation of the plane of subsurface or ground water, and the position of this ground-water plane often has a direct bearing on soil productiveness. Throughout a large part of the Visalia district ground water is within reach of the roots of trees, alfalfa, and other plants, being kept there by the water which sinks from natural and artificial channels in transit to lands irrigated and by the water which sinks into the ground on irrigated lands.

The method of applying water to the lands to be irrigated is generally by flooding, in small compartments or checks. These are adapted to the irregularities of the surface, being made rectangular when the surface is sufficiently level and smooth to permit of this arrangement. Crops cultivated in rows, such as beans, potatoes, and corn, also orchards and vineyards, are generally irrigated by running water in small ditches or furrows between rows. In the case of these products the soil is plowed or cultivated as soon after irrigation as practicable.

Here, as elsewhere in San Joaquin Valley, alfalfa is irrigated after each cutting (about every five or six weeks) so long as water is available. Orchards and vineyards receive water frequently during the spring months, and also in the summer if water holds out. Corn is irrigated once or twice, according to the condition of the ground at the time of planting. Grain is rarely irrigated; vegetables, very copiously and frequently.

No attention has as yet been paid to soil drainage. The many comparatively deep natural channels in the delta have kept ground water so far below the surface that the area in need of drainage is relatively small. As irrigation systems are further expanded throughout the delta it may be that subsurface soils will receive water more rapidly than it can pass off from them, and in such case improved drainage systems will become a necessity.


FRESNO RIVER
Madera
Fresno River Canal
S F & S J V
Borden
MADERA
R.18E.
R.23 E.
T.11S.
T.12S.
T.13S.
T.14S.
T.15S.
Collis
S P R R.
220
200
KINGS RIVER
ALTA IRRIGATION DIST.
Fortuna
R R.
Reedley
0 1 2 3 4 5

KINGS RIVER.

HYDROGRAPHY.

The drainage basin of Kings River above the eastern margin of San Joaquin Valley has an area of 1,742 square miles. The river's watershed extends to the main summit of the Sierra Nevada. Less than half of it is to be classed as low mountainous, all the rest being high mountainous country. The snowfall of the winter melts but slowly during the spring months, consequently the river reaches its ordinary high period late in spring or early in summer. The river is generally low from September to the end of January; it is at a medium stage during February, March, and August, and is high from the beginning of April to the close of July. The month of least flow during the six years 1878–1884 was November,[1] the average mean flow having been 313 second-feet, and the least flow for a single month 220 second-feet. The extreme low-water flow of the river has, no doubt, been somewhat below the least monthly mean. At medium stages the river carries 1,000 to 2,000 second-feet of water; during its high stages its monthly mean ranges from 4,000 to over 8,000 second-feet. The maximum flow of the river during the six years above named occurred in June, 1884, the extreme limit having been about 30,000 second-feet.

A gaging station was established on this river September 3, 1895, by the United States Geological Survey. It is located about 15 miles east of Sanger, 3 miles below Jarrett Ranch, and southwest of a hill well named Red Mountain. The station is equipped with a steel cable, car, and tagged wire.[2]

The results of these measurements show for the year 1896 a maximum discharge, which occurred in May, of 22,100 second-feet, and a minimum discharge, occurring in October, of 310 second-feet. The average discharge for that year was 2,582 second-feet. Similar figures for 1897 are as follows: Maximum discharge, 22,730 second-feet, occurring in May; minimum discharge, 250 second-feet, in September, with an average discharge for the year of 2,933 second-feet.

The Southern Pacific Railway Company has maintained gage-height readings at their bridge on the lower Kings River 1 mile from Kingsburg since 1879. The Geological Survey has taken a number of discharge measurements at this point, but owing to the shifting character of the stream it has been found impossible to construct rating tables for same.[3]

---

[1] See Physical Data and Statistics, Wm. Ham. Hall, State Engineer of California, pp. 452, 476.

[2] Bull. U. S. Geol. Survey No. 140, 1896, p. 286; Eighteenth Ann. Rept., Part IV, 1897, p. 390; Water-Supply and Irrigation Paper No. 11, 1897, p. 92; Water-Supply and Irrigation Paper No. 16, 1898, p. 191.

[3] Twelfth Ann. Rept. U. S. Geol. Survey, Part II, 1891, p. 320, Pl. LXXXII; Bulletin No. 131, 1895, p. 80, Bulletin No. 140, 1896, p. 284; Eighteenth Ann. Rept., Part IV, 1897, p. 393; Water-Supply and Irrigation Paper No. 11, 1897, p. 920; Water-Supply and Irrigation Paper No. 16, 1898, p. 192.

Estimated monthly discharge of Kings River at Red Mountain, California.

[Drainage area, 1,742 square miles.]

Month.	Discharge (in second-feet).			Total (in acre-feet).	Run-off.	
	Maximum.	Minimum.	Mean.		Depth (in inches).	Second-feet per square mile.
1896.						
January	11,020	390	1,474	90,682	0.98	0.85
February	1,140	728	825	47,477	.51	.47
March	7,020	820	1,710	105,181	1.13	.98
April	4,600	820	1,938	115,349	1.24	1.11
May	22,100	1,140	5,918	363,890	3.90	3.40
June	18,920	5,160	12,737	757,922	8.15	7.31
July	6,680	1,212	3,742	230,110	2.48	2.15
August	1,212	590	795	48,938	.52	.45
September	590	390	491	29,234	.31	.28
October	510	310	350	21,520	.23	.20
November	1,076	390	538	32,043	.35	.31
December	550	470	466	28,659	.31	.27
The year	22,100	310	2,582	1,871,605	20.11	1.48
1897.						
January	624	360	437	26,870	0.29	0.25
February	6,344	1,100	1,631	90,581	.96	.92
March	4,408	1,240	1,884	115,843	1.22	1.06
April	9,380	1,930	5,318	316,442	3.33	2.99
May	22,732	6,344	14,470	889,731	9.40	8.15
June	10,580	2,520	6,145	365,652	3.87	3.45
July	4,040	1,036	2,177	133,859	1.41	1.22
August	1,100	440	739	45,440	.47	.42
September	480	250	329	19,577	.20	.18
October	572	270	394	24,226	.25	.22
November	2,520	360	692	41,177	.44	.39
December	8,348	572	985	60,566	.63	.55
The year	22,732	250	2,933	2,129,964	22.47	1.65

Kings River enters San Joaquin Valley from the east about 20 miles east of Fresno. Before reaching Centerville Bottoms the river flows in a broad bed of cobbles from which the hills rise quite abruptly toward the north and toward the south. The hills retreat from the river somewhat at the upper end of Centerville Bottoms, forming a wedge-shaped valley that opens into the main San Joaquin Valley about 4 miles farther west, at Centerville. The northern portion of this Kings River spur of San Joaquin Valley may be regarded as a second or upper

bottom; the southern portion, lying at a lower level, is the upper division of Centerville Bottoms. These bottom lands, which have a length of about 9 miles, are depressed below the general surface of the San Joaquin Valley plain, being about 10 feet lower than the same at their upper limit and about 60 feet below the same at the Narrows, where the main valley plain drops in abrupt bluffs to the banks of the river as it emerges from these bottoms at their southeastern extremity. From this point southward for about 12 miles the surface of the main valley has greater fall than the river, gradually approaching its level, and near Kingsburg the bluffs upon either side of the river entirely disappear. It is here that the Kings River delta begins.

Through Centerville Bottoms the river flows in numerous channels,

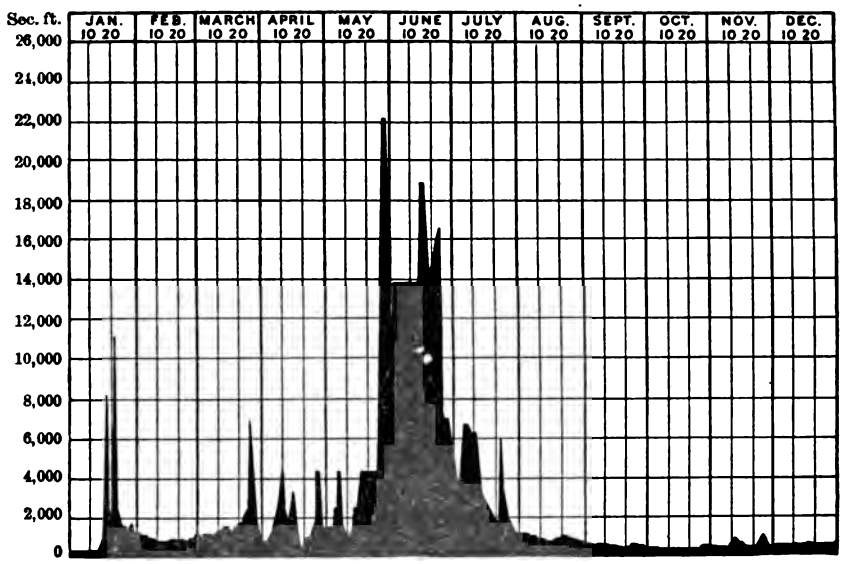


FIG. 9.—Discharge of Kings River at Red Mountain, California, 1896.

the main stream having a length of about 14 miles and a total fall in that distance of about 120 feet. The beds of these streams are for the most part formed of deposits of cobbles, gravel, and sand. Channel banks are rarely high or well defined. Below the Narrows the fall of the river is only 2 feet to the mile, which is maintained with reasonable uniformity to the outfall of the main channel into Tulare Lake.

From the head of Cole Slough, 2 miles south from Kingsburg, the main channel of Kings River has a southwesterly course for a distance of 35 miles to the trough of San Joaquin Valley; its course thence is south about 11 miles to Tulare Lake.

Cole Slough, the uppermost arm of the river thrown off toward the north, has a course nearly parallel with the main channel of the river for some miles, then flows northwesterly and, together with other delta

channels, delivers its water into Fresno Swamp, through which it flows into San Joaquin River. Kings River has but a single tributary below the point where it enters San Joaquin Valley. This is Wahtoke Creek, a small foothill stream which reaches the river from the east at the Narrows. Owing to scant rainfall, there is but little run-off from the lands of the plains, and this is, as a rule, away from the main stream and not toward it.

Canals and ditches from this river are to be divided into two principal groups, of which one embraces those which leave the river at the upper end of Centerville Bottoms and the other those of the delta. For

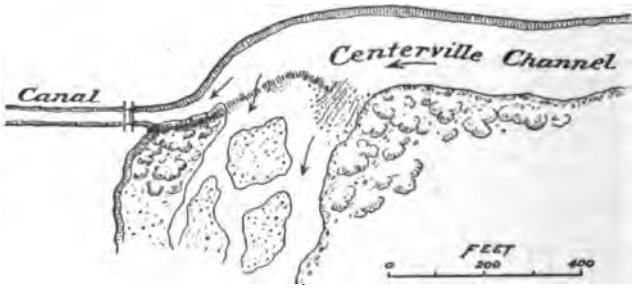


FIG. 10.—Head of Kings River & Fresno Canal.

convenience these groups may be again subdivided according to location of tracts irrigated, and will be treated under appropriate subheadings.

CANALS AND DITCHES.

Kings River & Fresno Canal.—This is the upper north-side canal from Kings River. Its head is 5½ miles above Centerville. The canal receives water through the head of a natural channel or arm of the river which has a position at the base of the low north-side slope that rises from the border of the river bottoms. Within a mile of its head the canal is carried in a cut northwestward out upon the surface of the second bottom, and a half mile beyond its water is dropped into a small natural channel known as Burns Slough. After flowing in this southwesterly for a mile, the water is carried westward in a cut less than one-half mile in length to Kip Slough, from which it is again reclaimed 1½ miles below. The course of the canal, now in an artificial channel, is thence westerly across Fanshaw, Red Bank, and Frolic creeks into the Dry Creek district northeastward from Fresno.

The cut from Centerville Channel of Kings River to Burns Slough has a bed width of about 30 feet. Below that point the canal width is quite irregular, ranging from about 15 to 24 feet. The flumes over creeks are 16 feet wide, with sides 3 feet high. The longest one is that across Red Bank Creek, which has a length of 96 feet. The fall of the main canal is far in excess of what might be considered necessary, its course being almost in the direction of greatest fall of the ground's

KINGS RIVER AT UPPER END OF CENTERVILLE BOTTOMS, LOOKING UPSTREAM.

surface. This results in no injury to bank lands in the upper section of the canal, where a firm substratum sets a limit to erosion, but has made the use of frequent check weirs or drops necessary in its lower sections, particularly at points where water is delivered into branches.

The construction of this canal was commenced in 1872. At that time a regulator was placed in its head at Centerville Channel of Kings River. The following year the cut to Burns Slough was made and the canal was extended westward upon the valley plain. The canal was intended primarily to supply water to landowners who had become stockholders in it, but the sale of water was not restricted to the stockholders. The company's capital stock was fixed at $100,000, in 1,000 shares. Water is sold at rates annually determined, not exceeding $50 per second-foot for stockholders and $75 per second-foot for other irrigators. The sale of water covers all expenses of management and repairs. The first cost of the canal was about $50,000.

As a result of adverse claims to the use of Centerville Channel the canal company was in conflict with the Fresno Canal and Irrigation Company until, in 1875, it was agreed that the water in the regulator of the Kings River & Fresno Canal should be maintained at 1 foot in depth during the low-water period of the river until there was less than 1 foot in depth in the regulator of the other canal, and that thereafter equal depths should be maintained in both regulators.

The distribution of water to ditches of consumers is in charge of a canal superintendent. No system of measurement is in use. Water is delivered to each ditch on the judgment of the superintendent in proportion to the number of second-feet to which each ditch is entitled. No attempt is made to effect actual delivery of the amount of water bargained for. Any number of irrigators may unite and have the aggregate amount to which they are entitled delivered through one gate.

The Enterprise Ditch was the result of such combination of interests. It was constructed about 1885. It received water for a time from the main canal at the point where its waters are dropped into Kip Slough, and takes a westerly course along the base of the north-side foothills. Rounding the point of these about 2½ miles north of Centerville, its course is northerly for 4 miles, thence westerly about 8 miles, generally 3 to 4 miles north of the main canal. This ditch was, a few years after construction, sold to the Fresno Canal and Irrigation Company in consideration of 40 water rights that were issued to its owners.

Fresno Canal.—The head of Fresno Canal is about 1½ miles below the head of the Kings River & Fresno Canal; also on the north side of Centerville Channel. A short artificial channel having a westerly course drops the water of the canal into Chambers Slough, which is a depression at the base of the low bluff at the northern margin of the bottoms. This has been converted into a section of the canal by the construction of a levee along its south bank to a point a little over a

mile from the head of the canal. There the canal enters Long Cut, which extends westward in a direct line a little over one-half mile and carries the canal water into another natural channel, Burns Slough, which connects with Kip Slough a short distance below. Long or Big Cut pierces the rimland which borders Centerville Bottoms on the north. It has a greatest depth of about 10 feet and a width of 65 feet. Kip Slough is utilized for the canal for a little over a half mile. It is thence carried westerly nearly 2 miles in an irregular natural depression, which was converted into a canal by constructing embankments along the south bank of the proposed water way. From this depression an artificial channel only about 500 feet long drops the canal water

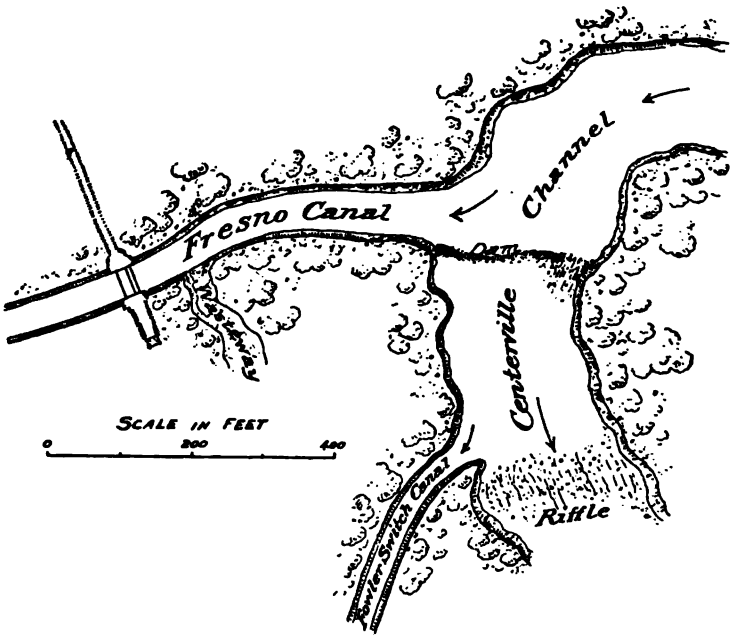


FIG. 11.—Head of Fresno Canal.

into Mud Creek, down which it flows in a southwesterly direction 3 to 4 miles to Fancher (Fanshaw) Creek, which then becomes the main channel of the creek to a point about 3 miles east of Fresno.

Where Fresno Canal leaves Kip or Lone Tree Slough the slough is closed by means of an embankment, in which a gate has been placed, through which water is delivered into the lower section of the slough, which is also known as the Kingsburg branch of Fresno Canal. This branch delivers water to the Highland, the Garfield (which also receives water from other sources), the McCall, and the Selma ditches.

The main canal may be regarded as terminating in the old sink of Fancher Creek, about 3 miles east of Fresno. From that point it sends southward its Washington Colony branch and southwestward

A. REGULATOR ON KINGS RIVER AND FRESNO CANAL

B. FOWLER SWITCH CANAL NEAR SANGER, LOOKING UPSTREAM.

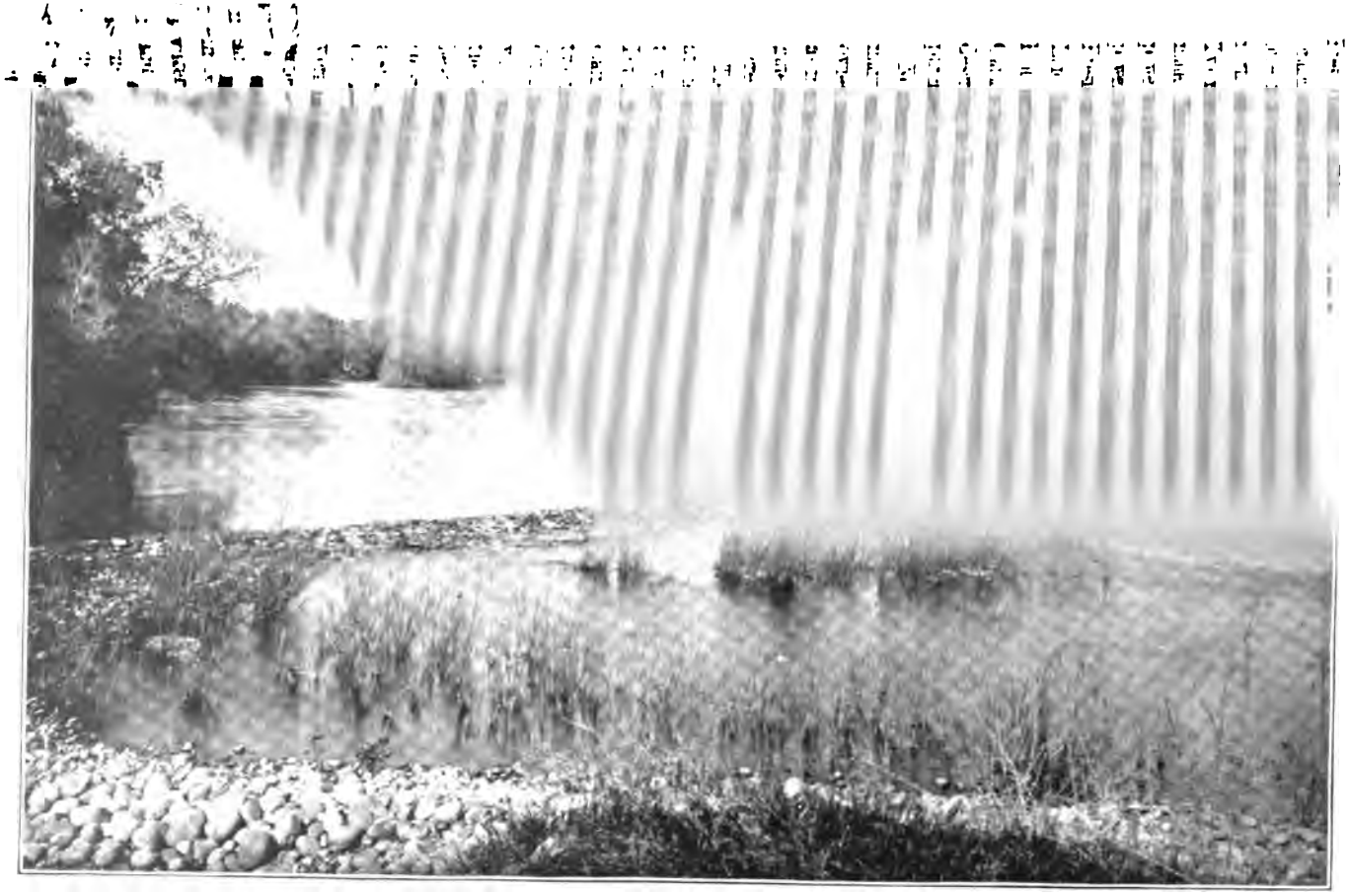
the Central Colony branch, from which there is another branch to Fresno Colony. At the Hobler Dam, about 8 miles east of Fresno, a branch is taken out toward the south and reaches Fowler and the colonies in its vicinity, and another branch is carried westward from the north side of the main canal to portions of the Easterby ranches. Two miles above the Hobler Dam the principal north-side diversion is made. This is known as the Mill Ditch, which for many years furnished power to a flour mill in Fresno, and delivered the water, after use for power, to the colonies southwestward from Fresno. The ditch through Fresno and this north-side branch has become the feeder of the Bank Land Canal, which conveys water northwesterly to a large tract of land northwest of Fresno. Another north-side branch of the Fresno Canal is the Enterprise Ditch, which has already been referred to in describing the Kings River & Fresno Canal (p. 43). This ditch was purchased for 40 water rights.

No attempt will here be made to describe or even to enumerate the many small branches of this canal, particularly as some of these are owned independently and often receive water from other sources as well as from the Fresno Canal. It may be sufficient to state that the aggregate area covered by water rights (each nominally 1 second-foot to 160 acres) exceeds 160,000 acres.

The history of this canal construction is not without interest. Operations on it commenced in 1870 with the posting of a notice of a claim to water "to be taken from Kings River at the upper end of Sweem's Ditch, 20 feet on the bottom, 30 feet on the top, 4 feet deep." This claim was made by Mr. M. J. Church, who a month later acquired a two-thirds interest in the Sweem Ditch. The Sweem Ditch was a small ditch, the construction of which seems to have been commenced in 1870, which was intended to increase the flow of what was then known as the Centerville Ditch. Its upper section was enlarged and became the head section of Fresno Canal. In 1872 a regulator or head gate was constructed in the head of the Fresno Canal, and in the spring of 1874 a small cut on the line of the present Long Cut was completed from the Centerville Ditch to the lower sections of the Fresno Canal, on which work had meanwhile been pushed to the limit of the means of the projector of the work, Mr. M. J. Church. This small connecting ditch is reported to have had a bed width of only 5 feet on a grade of 5 feet to the mile. As the alignment of a part of the older Centerville Ditch was in time to become the alignment of a section of the Fresno Canal, and because it seemed desirable to secure the water rights acquired by the Centerville people, arrangements were made to obtain control of the corporation known as the Centerville Canal and Irrigation Company, and a transfer of their ditch property was made to the Fresno Canal and Irrigation Company. This was in 1874. As soon, however, as the settlers near Centerville realized what their officers were doing the demands for just treatment at the hands of the Fresno Canal and Irrigation Com-

reg[illegible]
progress[illegible]
gained for, and[illegible]
Later their price w[illegible]

A water right, as [illegible]
thousandth part of the [illegible]
on a specified tract of l[illegible]
privilege of issuing 1,000 [illegible]
canal. Each purchaser of a water [illegible]
or permit it to be used, on any other land [illegible]
is purchased, nor to permit the water to run [illegible]
or in any other way to run to useless waste, and [illegible]
surplus waters back into the main canal or a branch [illegible]
water right remains subject to an annual expense asses[illegible]
ranges from $80 to $100. Water is delivered without any a[illegible]
measurement to each irrigator at any point on the company's
system that he may select. No transfer of a water right can be
except with the land which it covers. Each purchaser of a water
grants to the canal company the right of way for ditch and
purposes through any lands lying in the same township as the
for which water is bought, and concedes to the company the
to use his private ditch provided the company does not use it s[illegible]



COBBLESTONE AND BRUSH DAM OF FRESNO CANAL, KINGS RIVER.

interfere with the delivery of his water. The purchaser of a water right further obligates himself to pay to the canal company annually an agreed sum (this has usually been $100), and in default of payment for thirty days to forfeit his water right. The water-right agreement further sets forth that the company shall not be responsible for deficiency in water supply caused by drought, insufficiency of water in the river, hostile diversion or obstruction, forcible measures or temporary damage by floods or other accidents, but that it shall use and employ all due diligence at all times in restoring and protecting the flow of water in its canals.

The structures on the canal do not deserve extended notice. They are all made of timber. The original regulator has been replaced by a second one, constructed about 1884, shown in Pl. VIII, *A* and *B*. It consists of a substantial framework of heavy timbers, spaces between vertical posts being closed by vertical sliding gates. From the head gate an embankment of cobblestones, gravel, and sand extends northward across Centerville Bottoms to a connection with high land, and prevents destruction of the upper section of the canal during freshets. The diversion of water into the head of the canal is effected by means of a brush-and-cobblestone dam, as shown in Pl. VII, the maintenance of which in the past has not been expensive. Along the line of the canal, wherever necessary to prevent excessive erosion, or where required to turn water into a branch ditch, light timber weirs are in use. Most of these consist of two side or bulkhead walls and a floor, usually placed a little below the grade of the canal, and a line of vertical posts supported by braces from below. Spaces between posts are closed to the desired height either by fixed horizontal boarding or by movable drop timbers or boards.

The impression which the whole work gives is that of haphazard management, the result of which is not, however, entirely unsatisfactory.

The control of the canal long ago passed out of the hands of Mr. Church, who effected a profitable sale of the property. It is now managed by parties who also own controlling interests in the Kings River and Fresno Canal Company and who have acquired the property known as Rancho Laguna de Tache. It remains to be added that these parties as owners of the rancho, which is located on lower Kings River, have entered into a contract with the Sunset irrigation district under the terms of which, in consideration of a reservoir site, a right of way for a canal, and a waiver of riparian rights, the irrigation district has paid to the owners of the rancho $250,000 in bonds and has agreed to make no demand for water until 3,500 second-feet of water are available for the Fresno Canal and the canal of the rancho.

Centerville Ditch.—This is at present a branch of the Fresno Canal. It was constructed in 1868 and 1869 by settlers near Centerville (now Kings River). They organized a company known as the Centerville

Canal and Irrigation Company, which was incorporated in August, 1868. This company seems to have been the successor in interest to all rights acquired by some of the settlers whose first steps to secure water were taken in 1865. The canal was constructed southwesterly from a point near where the head of the Kings River & Fresno Canal now is about 2½ miles to Burns Slough; thence this slough was utilized for about a mile to a point a short distance below the Long Cut, and thence the ditch was extended southwesterly about 3 miles farther to lands at and west of Centerville. The canal property was transferred to the Fresno Canal and Irrigation Company in 1874, by those who had secured control of the stock, and the opposing minority interests were finally placated by the issuance of perpetual, unassessable water rights in the newer canal to stockholders who owned lands near Centerville.

Sweem Ditch.—This ditch was never completed. Its construction was commenced in 1870 from a point near the present head of the Fresno Canal, practically on the alignment subsequently adopted for that canal. Its purpose was to increase the delivery of water into Burns Slough for the Centerville Ditch. It was sold before completion to the parties who were at work on the Fresno Canal project, and within a few years it was transformed into a large canal, as already explained.

Fowler Switch Canal.—The head of the Fowler Switch Canal is in Centerville Bottoms, about 100 yards below the head of the Fresno Canal. Its course is southwesterly for 1½ miles in Centerville Bottoms, thence westerly for 2 miles across the second bottoms to near the channel of Lone Tree Creek, thence southwesterly 10 miles and southerly 5 miles to a point about midway between Fowler and Selma, thence southwesterly 5 miles, thence northwesterly into the district southward from the Washington Colony. The canal is said to have been built to carry 1,500 second-feet. Its bed width is about 45 feet, its depth variable. The gradient is very irregular, being that of the natural surface of the ground in its upper sections, where a quite firm hardpan formation is relied upon to check excessive erosion of the canal bed. Near the lower end of the canal it was given a fall of 1.92 feet to the mile.

It was proposed to use no check weirs to reduce the fall, which for short distances was as great as 12 feet to the mile, and to put lateral ditches at a lower elevation than the main canal, so as to reduce the necessary structures to a minimum. It was soon found, however, that weirs would be necessary at some points to check erosion and at most points where water was to be diverted.

Among the branches of the Fowler Switch Canal may be mentioned the Cleveland Ditch, about 5 miles long, which delivers water to lands midway between Malaga and Fowler; the Western Canal, which supplies water to lands adjacent to and immediately south of the Sierra

A. REGULATOR OF FRESNO CANAL ON KINGS RIVER, AS SEEN FROM ABOVE.

B. REGULATOR OF FRESNO CANAL ON KINGS RIVER, AS SEEN FROM BELOW.

Park and Washington Colony; the Grant Ditch, which has a westerly course for 4 or 5 miles from near the end of the main canal; and the Elkhorn Canal, which has a southwesterly course and delivers water to the western portion of the Wildflower region. The entire canal system gave promise of being one of considerable importance to the prosperity of the district it commanded, but hopes have not been fully realized. The canal has not been permitted to take river water without protest, and unfavorable court decisions have thrown some doubt upon the reliability of this canal as a source of supply.

This canal was constructed in 1883. Farmers in the vicinity of Fowler who wanted water for their own lands formed a corporation,

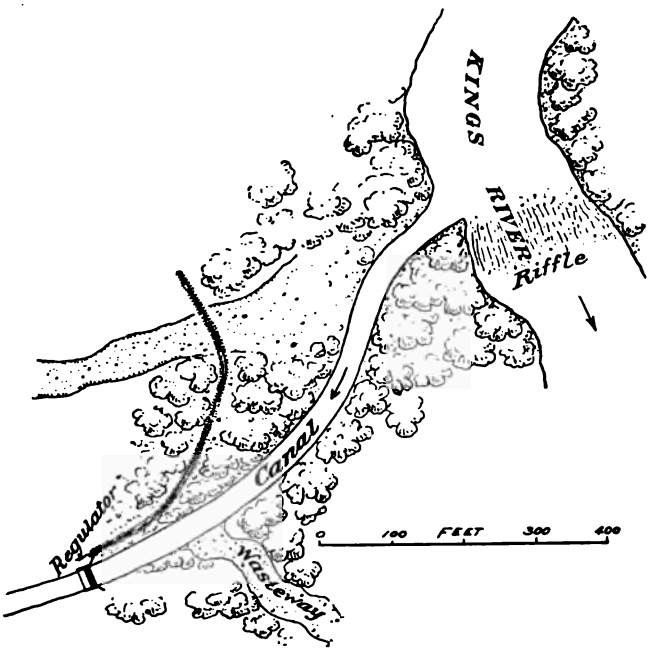


FIG. 12.—Head of Fowler Switch Canal.

the capital stock of which was fixed at $450,000, divided into 1,500 shares, of which 300 were subscribed for. It was agreed that in payment for each share labor and material might be contributed to the extent of $200, the remainder to be paid in coin. It was soon found, however, that the first issue of shares would not cover the cost of canal construction, and it was followed by a second issue of 300 shares, which were taken by the same persons who held the first issue. About $110,000 were expended on canal construction in the first two years.

The water in the canal is apportioned to the stockholders, who may ask for the delivery of their water at any point on the main canal. This has led to the construction of a number of branch ditches under

independent management, which receive their water from the main canal. One of the principal branches of this sort is the Elkhorn Ditch. It is owned by a company in which thirty shares are represented. Some of the stockholders in the Elkhorn Ditch Company are not holders of Fowler Switch stock. In such cases they are required to buy their water from some stockholder. The use of the Elkhorn Ditch is restricted to its owners, no water being sold.

The water represented by the stock of the Fowler Switch Canal Company is at the disposal of the individual stockholders to the extent that it may be leased or sold and its delivery may be called for through any branch ditch. No system of water measurement or special design of gate has been prescribed. All gates in distributing ditches are constructed by the consumers. The delivery of water through these gates is in charge of a canal superintendent. The canal company itself does not sell any water. All expenses are met by assessing the stockholders.

The structures on the canal do not merit extended notice. They are all of very light construction. The check weirs or drops are V-shaped, upper and lower faces being permanently sheathed with light boarding. There is no diverting dam at the head of the canal, which has been located just above a natural cobblestone-and-bowlder riffle.

Centerville & Kingsburg Canal.—This is another of the important north-side canals from Kings River belonging to the upper group of canals. Its head is about 2 miles in a direct line northeast of Centerville, and about the same distance by river below the head of the Fowler Switch Canal. Its course is westerly for nearly half a mile, directly toward the northwestern margin of Centerville Bottoms. Its second half mile has a southwesterly direction, along the slope from higher plains to the bottoms; thence on the higher level it holds a course southwesterly and southerly for about 8 miles, practically parallel with the bluff, 20 to 30 feet high, which drops from the valley plain to Centerville Bottoms. This portion of the canal is frequently within a few rods of the edge of the bluff, and is rarely more than half a mile distant therefrom.

About 9 miles below its head the canal is separated into a number of branches, which radiate throughout the district westward from Kings River below the Narrows, extending southeastward to lands east and south of Sanders, southward to the vicinity of Kingsburg, and southwestward beyond Selma and well into the Wildflower country.

The main canal has irregular dimensions, its bed width being generally about 30 to 35 feet. It has been allowed to cut deep into the friable surface soils in the upper sections of its course, where but little attempt has been made to reduce its gradient below that of the natural surface of the ground. The length of main canal is about 18 miles. The length of its three principal branches is reported at about 26 miles.

The diversion from the river is effected by means of a brush-and-cobblestone dam, in which a small gate serves as waste way and sand

A. REGULATOR ON FOWLER SWITCH CANAL, AS SEEN FROM ABOVE.

B. REGULATOR ON FOWLER SWITCH CANAL, AS SEEN FROM BELOW.

sluice. The canal regulator is close to the river and is of a type very common on Kings River canals. Three rows of posts rising from a plank floor extend across the canal from one bulkhead wall to the other. They support a platform loaded with cobbles and gravel to give stability to the structure. The spaces between upper posts are closed by means of vertically sliding gates, each of which has a stem extending above the platform, to which power is applied when the gate is to be opened or closed. The cost of the regulator was about $1,000. The first cost of the canal was about $35,000.

This canal was constructed in 1877 and 1878. It was built by a company organized by farmers who owned lands near Kingsburg and Selma. The capital stock of the corporation which they formed was originally fixed at $12,500, but was subsequently increased to $35,000, being divided into fifty shares. The upper 2 miles of the canal were constructed by day labor. The rest of the main canal was divided into

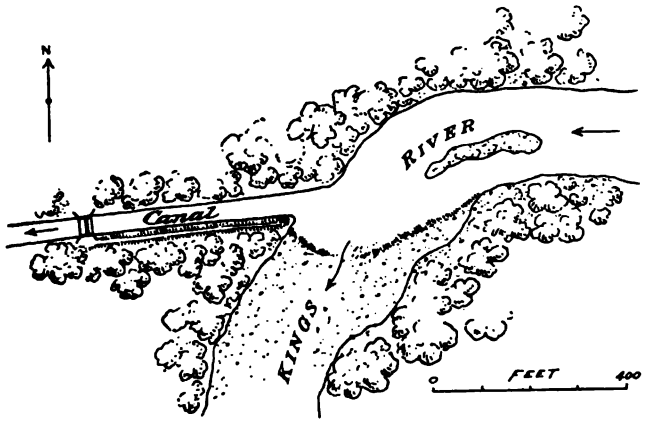


FIG. 13.—Head of Centerville & Kingsburg Canal.

sections, each of which represented one share of stock, and was assigned to some stockholder, who was required to complete it. A few unlimited, unassessable rights to water from the canal have been granted to settlers near Centerville, in consideration of rights of way. Each stockholder is entitled to the delivery of a proportional part of the water remaining available for distribution; but each stockholder, or the corporation when in possession of any shares of stock, may lease the shares. The price of a share per month in 1882 was $6. Shares were at that time valued at about $1,500. Each share of stock is supposed to represent "3 feet of water;" an expression of quantity which seems as vague as the amount named in the franchise of the company—"150 cubic feet of water under a 4-inch pressure." In fact, however, each share of stock entitles its holder to a proportional part of the water varying somewhat according to the number of shares in actual use, but not in excess of three times the amount which would flow 4 inches deep

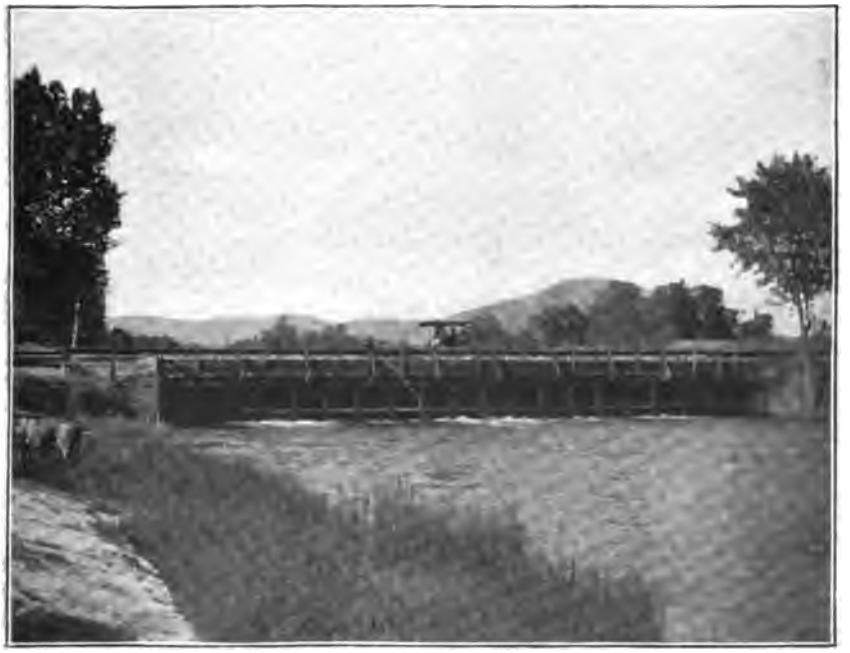
over a clear overfall 12 inches long. Water is apportioned on the judgment of a canal superintendent, generally through gates of like construction. When the amount of water per share of stock in the canal exceeds three units, each indicated by a clear overfall of 4 inches on a length of 12 inches, then all surplus water is held for sale, by the directors of the company, at fixed rates per month per unit. The cost of canal management, maintenance, and repairs is assessed upon the stockholders. The annual expense assessment is now about $80 per share of stock. The works required to divert water from the main canal into private ditches, including weirs in the main canal, are constructed by the consumers of water, subject to approval of the canal company.

Satisfactory use of this canal has been interfered with to no little extent by litigation, generally involving the right of the canal to receive water from the river, and, as in the case of other canals from Kings River, its permanent efficiency as a source of supply has been thrown somewhat into doubt by adverse decisions of the courts.

Selma irrigation district.—This irrigation district is situated on the north side of Kings River, in Fresno County, and embraces within its limits the lands now watered by the Fowler Switch and the Centerville & Kingsburg canals. It was organized in 1890 with an area of 271,000 acres. For the purchase of existing canals and the construction of new works, it was proposed to issue bonds to the amount of $1,000,000; but the bond issue was twice defeated at the polls, and it seems to be generally conceded that there is small probability of a continuation of operations under the district law.

Alta irrigation district (76 Canal).—The canal which supplies water to the Alta irrigation district is known as the 76 Canal. It belongs to the upper group of Kings River canals. Its head is on the south side of the river, about 1½ miles above the head of the Kings River & Fresno Canal, if the point at which the uppermost work for the direction of water toward the canal regulator may be termed its head. At that point a branch of the river has been enlarged somewhat and otherwise improved, and the water diverted from the main stream through this natural channel is carried in a succession of depressions or high-water channels along the southeastern margin of Centerville Bottoms about 3 miles, to the point where the canal cuts out upon the higher plain lying to the east of Centerville Bottoms. The natural depressions of the upper coal section have in large part been converted into a canal by building up, along their low western banks, embankments of cobblestones and bowlders, which were taken from their beds for their enlargement. Where the canal turns away from Centerville Bottoms a cut 9 feet in depth was necessary. From this point the canal has a general southeasterly course, following a grade line with 18 inches fall to the mile, that skirts the western foothill base. At 6 miles below the regulator the canal is carried across Wahtoke Creek, and its southeasterly

A. REGULATOR ON SEVENTY-SIX CANAL, AS SEEN FROM ABOVE.



B. REGULATOR ON SEVENTY-SIX CANAL, AS SEEN FROM BELOW.

course is maintained about 22 miles farther, to near Cottonwood Creek. The main canal has been made the eastern boundary of the Alta irrigation district.

The bed width of the canal throughout the first 9½ miles below the regulator is 100 feet. Its capacity, with a depth of 5 feet of water, is about 1,200 second-feet. From the main canal numerous branches extend southwesterly and southerly into the heart of the district. The principal of these is the Traver branch, which has been given a bed width of 60 feet. It leaves the main canal about 1½ miles below Wahtoke Creek, and, as its name indicates, delivers water to lands in the vicinity of Traver. Branch canals are for the most part located across the valley plain on lines of its greatest slope. They have generally been given positions on high ground intermediate between gentle depressions, though in some instances, as in the case of the Traver

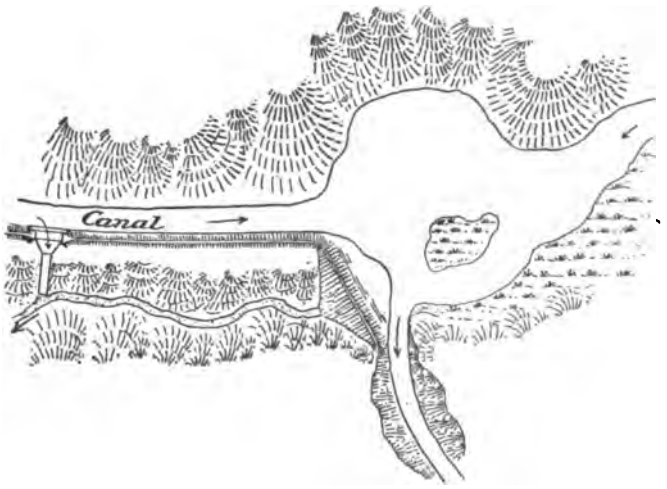


FIG. 14.—Wahtoke Reservoir, on 76 Canal.

branch, natural water courses have been in large part substituted for expensive canal work.

The inflow of water from the upper canal section into the second section of the main canal is controlled by means of a regulator or head gate. Above the regulator in the west canal bank is a spillway through which surplus waters are dropped into Patterson Slough, one of the Kings River channels in Centerville Bottoms. The regulator rises from a plank floor constructed of two layers of 3-inch planking, the dimensions of which are 100 feet in the direction across the canal by 30 feet along its axis. The surface of the floor is at grade of the canal bottom. Along its upper and lower edges are two lines of sheet piling, not driven, but constructed in trenches, which extend to a depth of 5 feet. The bottom ends of the sheeting planks are nailed to a horizontal plank 3 by 12 inches, which adds to the effectiveness of the sheeting. Trenches were

refilled with carefully selected material well tamped into place. Three rows of posts, with necessary brace timbers, rise from this floor, the post rows being 8 feet apart. They support a platform which serves as a bridge. Between the upper posts are the gates, twenty in all, which slide vertically in grooves formed by spiking additional timbers to the upper faces of the posts. Each gate has a stem to which power is applied by means of a lever. Every fourth gate is provided with two vertical revolving shutters, so connected with it that when closed they will not interfere with the free movement of the gate. These shutters are intended to be used when the water pressure on the gates is so great as to interfere with their being raised. The cost of the head gate was $3,000. Lumber at the gate costs $28 per thousand feet, board measure. About 60,000 feet of lumber were used in its construc-

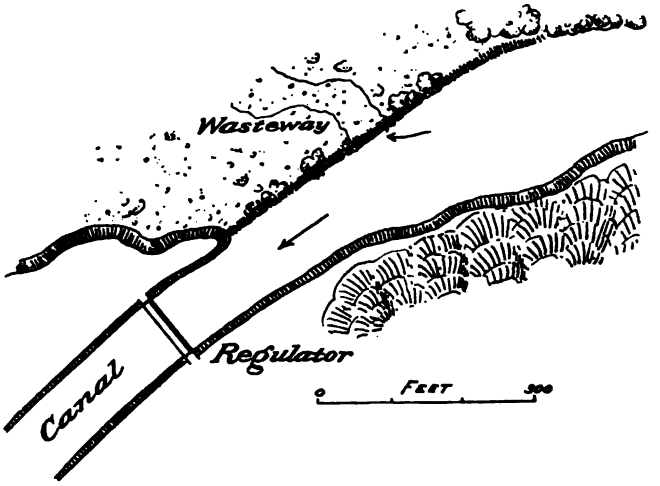


FIG. 15.—Head of 76 Canal.

tion. The check weirs in use on this canal system (there are nine on the Traver branch within 7½ miles above Traver) are simple but serviceable structures. They are of the flashboard type. Spaces between posts 4 feet apart, which rise from a plank floor, are closed by loose boards sliding in grooves. The cost of a check weir across a canal 60 feet wide is reported to have been $275.

Occasionally a firm hardpan layer that would not yield readily to blasting or plowing had to be broken up into long, narrow strips with gads. A spur of rotten granite was crossed at one point, and the maximum cut through it was 28 feet. Throughout 5 miles below the regulator large cobbles—some 1 foot in least diameter—had to be removed from the material loosened by the plow before scraper work could commence. The ground containing these cobbles was first trenched with large road plows drawn by 12 to 16 mules. The plows were steadied by means of long saplings extending out on either side.

Along the base of Campbells Mountain, throughout the 3 or 4 miles above Wahtoke Creek, the surface soil into which the canal was cut is dry bog—a dark-colored, light soil, which contracts, cracks, and crumbles in drying. When wet this soil is soft and sticky. This material had to be used in many places for the canal embankment, which often crossed depressions, and when water reached these it rapidly permeated the spongy bank and often found vents that led to the speedy destruction of the embankment. It cost about $6,000 to get the water in the canal as far as Wahtoke Creek.

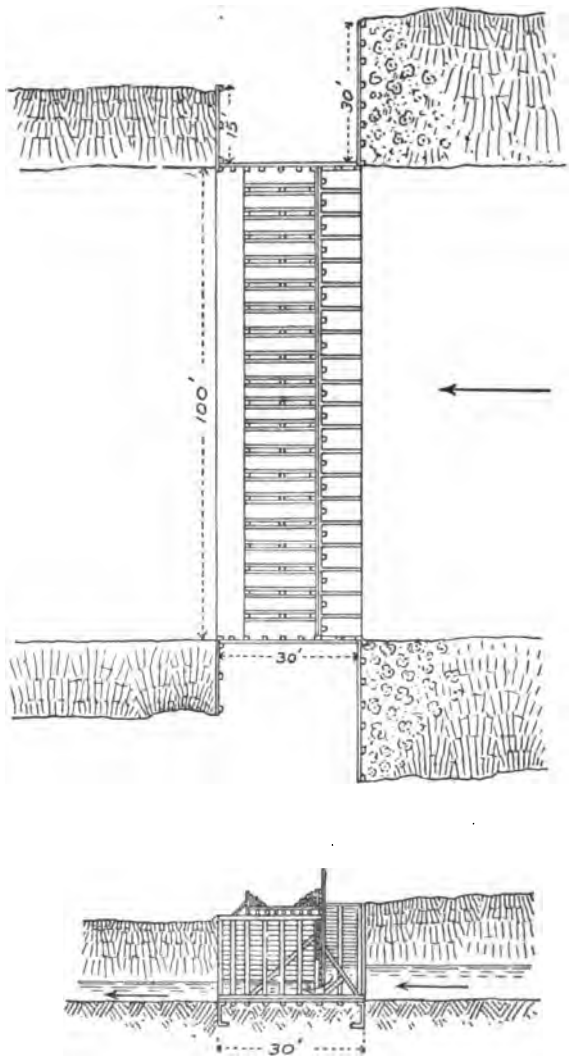


FIG. 16.—Plan and elevation of regulator for 76 Canal.

The canal was constructed in 1882. This was before the enactment of the irrigation-district law. Its construction was undertaken by a private corporation, on a plan which was very satisfactorily carried out. As soon as the feasibility of making the diversion of water from the river was assured, about 40,000 acres of land on the plains to be commanded by the canal were bought for the corporation at prices less than $10 per acre. These lands were offered for sale as soon as the canal came into service, at prices somewhat in excess of the added cost of canal construction. It was proposed to establish each year a schedule of prices to be adhered to for a year, but demand for land was so great at the prices fixed during the first few years that the lands were

repeatedly withdrawn from sale. The expenditure of less than $300,000 in four years thus created and increased values to an estimated amount of over $800,000, not including increased values of properties in which the canal company had no direct interest.

Before the canal was sold to the Alta irrigation district, water rights were issued to purchasers of all lands sold by the canal company and were for sale to others owning land in the district commanded. A water right was defined as 40 miner's inches of water, and was located upon some particular 40-acre tract of land, of which it became an appurtenance. Each full water right was made liable to an assessment of $16 per year to cover expenses of canal management. The price of a water right was fixed at $200.

The Alta irrigation district was formed in 1888 and was made to include the lands to be irrigated with the 76 Canal. It extends southerly from Kings River to and even beyond Cottonwood Creek and westerly to within a mile of the eastern border of the Kings River delta, and has an area of 130,000 acres. Two years later the district purchased the canal and its branches, paying therefor $410,000 in bonds of the district. This covered the repayment to holders of water rights of the amounts which they had paid for them.

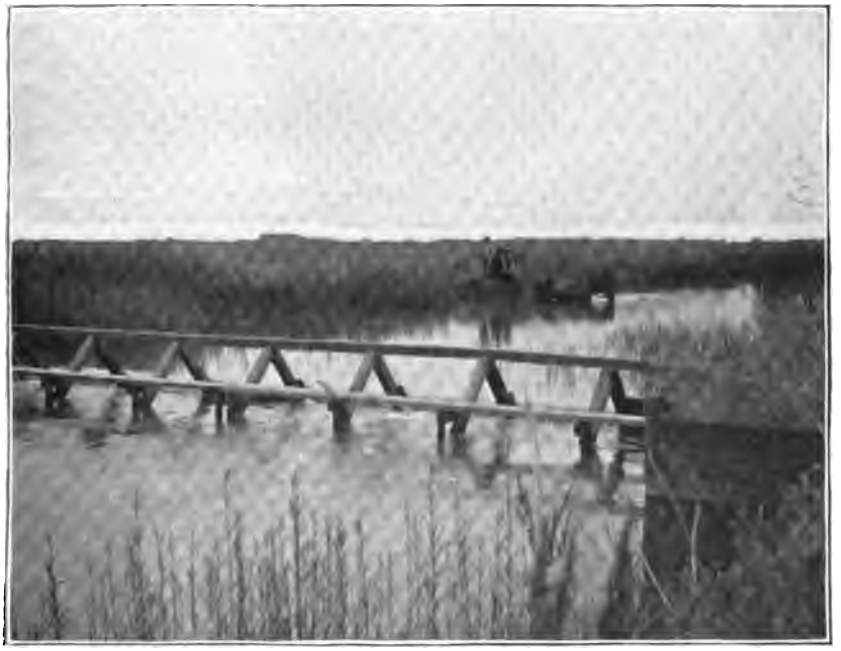
The northern apex of the Alta irrigation district is at the western base of Tchoenimne Mountain, where a second river bottom, 10 to 20 feet higher than Centerville Bottoms, lies below the 76 Canal. From the second bottom, which is long and narrow, having an area of nearly 7,000 acres, there is an abrupt rise of 20 to 35 feet to the upland or main east-side San Joaquin Valley plain. The surface of this plain drops away gently from the base of the hills southwestward toward the valley trough. Its slope is at first about 10 feet to the mile, but this becomes gradually less and is only 6 feet to the mile near Traver. The only notable break in the surface of this portion of the valley plain is made by Wahtoke Creek, which, in its southwesterly course from the foothills of the Sierra Nevada, passes to the east and south of Campbells Mountain and discharges into Kings River at the Narrows. It flows in a wide, deep gorge from foothill base to the river.

Southward from Wahtoke Creek are several minor creek channels, which carry water only in very wet seasons and sink or spread before reaching Cross Creek.

After the purchase of the 76 Canal system, in 1890, more branch canals were necessary. These were constructed, under the direction and supervision of the district engineer, by private parties, from whom they were then bought, payment being made with irrigation-district bonds. About 150 miles of branch ditches were thus constructed, at a total cost in bonds of $133,000. The entire district is now covered with branch canals, which are rarely more than 2 to 3 miles apart.

The area of land to whose surface water is now actually applied is estimated by the district officers at 40,000 acres. The distribution of

A. FURROW IRRIGATION FOR CITRUS FRUITS.



B. CHECK WEIR IN ALTA IRRIGATION DISTRICT, IN LATERAL ABOUT TWO MILES WEST OF TRAVER.

water is in charge of a canal superintendent and seven assistants, called "ditch tenders."

The soil of this region is for the most part a sandy loam, with coarse, clayey sands near the eastern border of the district, and finer, lighter sands toward the west. Much alkali is in the soil to the west and southwest of Traver. Hardpan subsoils are common at 2 to 5 feet below the surface. Ground water before 1883 was at 20 to 60 feet. It was nearest the surface in the southern and western portions of this district. Irrigation is causing the water table to rise, particularly near Traver.

Water is usually available for irrigation from February until the end of July. Where used on a small scale, land is occasionally prepared for it by subdivision into small rectangular checks. This was the preferred system when water was first introduced into the vicinity of Traver. Now the contour-check method of irrigation is finding more favor. The reason for this preference seems to be due, not only to reduced first cost, but also to the fact that it requires less cutting down of surface soils than the level-check method of irrigation. The uncovered subsoils are often found to be relatively barren. Orchards, vineyards, and summer crops are quite generally being irrigated by the furrow method. Grain land, if wet at all, is irrigated by spreading water over the surface from small ditches or furrows, usually before sowing.

Morrow Ditch.—This was one of several small private ditches south of the main channel of the river which were in use for the irrigation of small tracts of land in Centerville Bottoms. It was constructed about 1865.

Dennis & Jordan ditch.—This is another private ditch, now having the appearance of a natural arm of the river. Its course is southwesterly from Patterson Slough, from which it takes water about 1½ miles below the regulator of the 76 Canal.

Kincaid Ditch.—This name is applied to an eastern arm of Patterson Slough, the head of which is about one-half mile below the head of the Dennis & Jordan Ditch. It supplies water to the Dennis Ditch and to Finks Branch.

Glenn and Barton ditches.—These are two other small private ditches, which seem to have been in use about 1879 on lands of Centerville Bottoms, but which have probably been abandoned.

Emigrant Canal.—This canal may be classed as almost out of service. It was the uppermost of the north-side Kings River canals of the lower group. It took water from the north side of Cole Slough about 2 miles below the head of that arm of Kings River. Its course was southwesterly, nearly parallel with Cole Slough, for about 3 miles, thence northwesterly to and beyond Wildflower. The canal was constructed by an organization of farmers who wanted water for their lands, and was to be managed for mutual benefit. They formed a cor-

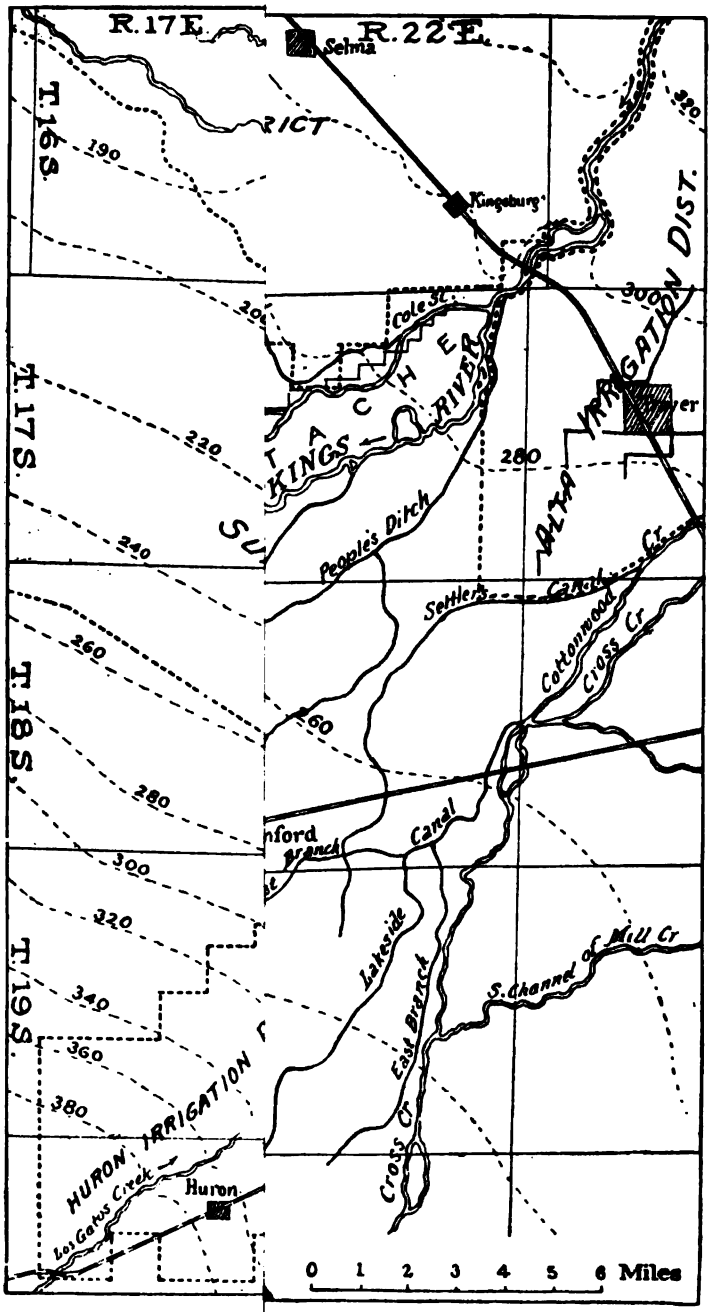
poration late in 1875, with a capital stock of $20,000, in shares of $1,000 each. All expenses of construction, maintenance, and management were met by assessing stockholders. Each stockholder was entitled to the use of canal water in proportion to amount of stock owned. He was allowed to sell or rent his water at pleasure. Each consumer of water was required to build his own delivery gate, subject to the approval of the directors. The distribution of water was in charge of a canal superintendent, which office was annually let to the lowest bidder. The canal had a bed width of about 16 feet, and delivered its water to a number of branches, which covered about 7,000 acres. The canal company became involved in litigation and failed to maintain control of its head works, so that finally it received water only during high stages of the river, and generally for such short periods of time that those dependent upon it soon found it to their advantage to secure additional water from the Centerville & Kingsburg or the Fowler Switch canals.

Liberty Canal.—This is a canal which was constructed about 1882 from the north side of Murphy Slough, its head being about 5 miles above Riverdale. After experiencing much trouble in obtaining a satisfactory supply of water from Murphy Slough, which is the extension of Cole Slough, the original head of the canal was abandoned several years ago, and it was extended easterly about 7 miles to a connection with a high-water escape way from Cole Slough known as the Sutherland Canal. The inflow into the canal is controlled by a regulator placed in the Sutherland Canal about one-eighth mile from Cole Slough. The canal is about 15 miles long, has a westerly course for 7 miles and thence a northwesterly course, is about 20 feet wide, and its branches cover about 5,000 acres to the north of Riverdale.

Millrace Canal.—Where Murphy Slough leaves the grant known as the Rancho Laguna de Tache, about 1½ miles above Riverdale, two gates or flashboard weirs have been built across the two channels of the slough. These force its water through a short canal into another natural channel, known as the Old North Channel, from which it is reclaimed half a mile below and is carried westward and thence northward in the Millrace Canal. This canal is used for the irrigation of lands near Riverdale and westward thereof. It is essentially a high-water canal. The canal proper is about 6 miles long. It has a bed width of about 14 feet.

Reeds Ditch.—One of the old ditches on Kings River is the Reeds Ditch, whose head is on the north side of Murphy Slough, about 4 miles below Riverdale. It is a small private ditch, having a course a little north of west. Its bed width is about 5 feet; its length about 4 miles. It irrigates a few acres of land near Elkhorn.

Laguna de Tache Canal (Grant Canal).—The "River Ranch," which includes the Rancho Laguna de Tache, has an area of about 68,000 acres, embracing within its boundaries nearly all of the delta lands


R.17E.
R.22E.
Selma
Kingsburg
T.16S.
T.17S.
T.18S.
T.19S.
190
200
220
240
260
280
300
320
340
360
380
Cole St.
KINGS RIVER
Peoples Ditch
Settlers Canal
Cottonwood Cr.
Cross Cr.
Lakeside Canal
East Branch
S. Channel of Mill Cr.
Cross Cr.
ALTA IRRIGATION DIST.
HURON IRRIGATION
Los Gatos Creek
Huron
0 1 2 3 4 5 6 Miles

of Kings River northward from the main stream. A main canal has been constructed for the irrigation of the greater part of this rancho, and this is known either as the Laguna de Tache Canal or the Grant Canal. A large portion of this rancho is annually submerged during the high stages of Kings River. The area subject to such flooding has, however, been considerably reduced by the construction of a north-side river levee along a portion of the ranch frontage. There are a number of north-side delta channels which break out from the main stream within this rancho, most of which have westerly courses toward the valley trough. The history of these, as related by local residents, is not without interest. The present head of Cole Slough is a water way made by the freshets of 1861–62. It was enlarged and deepened by subsequent high waters. Cole Slough is the principal north-side delta channel. Its waters are carried westward by the several branches of Murphy Slough, and finally reach the upper portion of Fresno Swamp, through which they are carried in a network of channels, as frequently found in tule swamps, to Fresno Slough and San Joaquin River, many miles northwestward.

Before 1862 Cole Slough received water from the river through a channel known as the Arroyo de Hotansas, the head of which was about a quarter of a mile below the present head of the slough. This channel was about 3 miles long.

Until 1869 Cole Slough occupied a channel which at a point about 3 miles in a direct line above Kingston was less than a quarter of a mile from Kings River, but in that year Mr. St. John, one of the owners of the rancho, made a small ditch westward from the north slough bank about 6 miles below its head. This ditch was enlarged by the next high water; it lost the appearance of a ditch, and is now called St. Johns Channel or New Cole Slough. It reunites 3 miles below its head with the original slough channel at a point also known as the head of Murphy Slough.

A small ditch, constructed in 1868 by a settler known as Dutch John, connecting Kings River with Cole Slough at the point where the two channels were nearest together, had meanwhile also been converted into a capacious water course and has since been known as the Dutch John Cut. In the same winter, 1868–69, the river broke through the barrier separating it from Murphy Slough at a point about 3 miles (by river) below the Dutch John Cut and formed Reynolds Slough, which is about one-half mile long.

The Grant Canal was constructed in 1873. Water was diverted for it from Murphy Slough, near Reynolds Slough, which latter was permanently closed by means of a dam. Two years later, by permission of the owners of the Grant, a new connection between Cole Slough, half a mile above the head of Grant Canal, and Murphy Slough, nearly the same distance below the canal, was made by settlers who were desirous of increasing the flow of water in the channels

reaching the vicinity of Elkhorn. Its projectors subsequently filed a claim to water and incorporated under the name of the Vanderbilt Canal Company. Settlers in the vicinity of Riverdale and Elkhorn claim that the original cut was entirely artificial, while owners of the Grant Canal claim that the cut is merely the result of cleaning out the head of a natural water course. After the Vanderbilt Cut had become one of the channels for Cole Slough water, the Grant Canal was extended upstream across Murphy Slough to the Vanderbilt Cut, from which it has ever since taken its water. The turning of the flow of Cole Slough into the Vanderbilt Cut is accomplished by means of a dam of earth across the old south channel. From the cut water is turned into the head of the canal by means of a second earth dam, and, flowing in the canal, it crosses Murphy Slough between two dams, of which the lower or westerly one is an overfall dam of brush work, serving as an escape

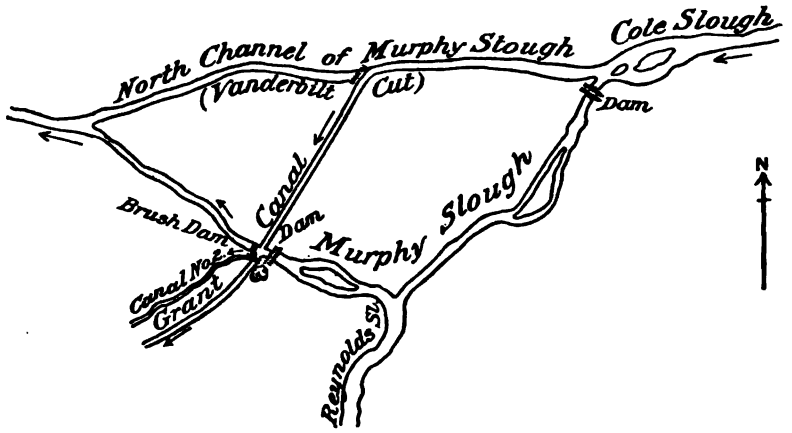


FIG. 17.—Head of Grant Canal.

way for surplus waters and feeding the lower sections of Murphy Slough.

The Laguna de Tache Canal has a westerly course along the northern bank of the main channel of Kings River, from which it is generally less than one-half mile distant. At 5½ miles below its head it crosses a water course known as the James Canal, on an earthen dam, and its direction becomes southerly. It reaches the river bank within a mile and closely follows it southerly for about a mile farther on its course, crossing and closing the head of another delta channel of Kings River known as Old North Fork.

The upper section of the main canal for a distance of about 4 miles from its head has a bed width of about 30 feet and carries water 2 to 2½ feet deep. The distributaries from the main canal are for the most part natural channels, many of which have long ago ceased to serve as delta channels and are mere swales on the tops of low ridges. The James Canal is a channel of more recent formation, which has been

utilized as a distributing ditch. By permission of the owners of the Grant a gate for the control of its flow was put into this channel in 1880. It was washed out by the next freshets and was replaced in 1881, but was again destroyed. Thereupon the owners of the Grant permanently closed this channel with the embankment of earth on which the canal is carried across.

The head of Old North Fork, which is another distributary of canal water, was closed as early as 1865 by Messrs. Sutherland and Mann. One of the most important of the lower-river north-side delta channels is the Zalda Canal, which, throughout its lower sections, is generally known as the North Fork of Kings River. It is claimed that the head of this channel is the enlargement by flood waters of a ditch constructed in 1872 by settlers living to the west of the Grant. This channel was reported closed for a time by a dam at the river about 1885. It was at that time proposed to utilize this channel as one of the distributaries of water from the Grant Canal. The course of North Fork is westward in a very direct line toward Summit Lake, but before the lake is reached its main channel swerves northward into Fresno Swamp. The portion of the Kings River delta between the main river on the south and the Zalda Canal on the north marks the very flat summit between Tulare Lake and Fresno Swamp. In the trough of the valley near and to the south of Summit Lake the general elevation of the ground's surface on this summit, the lowest point on the border of Tulare Lake, is about 211 feet above mean sea level. During the last high stage of the lake, in 1868, the depth of water over the general surface of the country at this point was about 6 feet.

The lands of the Rancho Laguna de Tache have always been so well watered that the irrigation works which have been constructed may be regarded as serving primarily to establish a convenient control of the water rather than as works intended to increase the supply. To prevent excessive natural inundation it has been found necessary to erect embankments along the river, also to construct numerous drain ditches from low tracts into natural channels to facilitate drainage. The main irrigation canal supplies water to a large number of distributaries, frequently natural channels, and these in turn to small irrigating ditches, usually 200 to 450 yards apart. As the entire irrigation system lies within the limits of the rancho there has been less study of methods of controlling and distributing water than would have been the case if a large number of consumers had to be supplied, and water measurement has been entirely out of the question.

The Rancho Laguna de Tache has within the last few years become the property of the same parties who control the Fresno Canal. The future of both properties was kept in mind when the owners of the Grant sold Kings River water to the Sunset irrigation district, to be diverted by way of Cole Slough into the enlarged Grant Canal, thence across the Zalda Canal (North Fork) to a proposed reservoir near Summit Lake.

According to the terms of this agreement the district is given a right of way and a reservoir site, and water is sold to it to the extent of 3,500 second-feet, subject to the prior rights of the owners of the rancho and of the Fresno Canal to the extent of 3,000 second-feet, and subject also to the proviso that, for use on the ranch, 500 second-feet may be taken out of the main canal of the district. The price paid by the irrigation district was $250,000 in district bonds, and the aggregate amount of land in reservoir sites and right of way for the canal was not to exceed 2,200 acres.

Crescent Canal.—This canal was constructed in 1885 and 1886, and came into use in 1887 for the irrigation of lands on the western edge of the extreme southern portion of Fresno Swamp. The head of the canal is on the south side of North Fork, about a mile to the north of Summit Lake. The canal, which is about 8 miles long, has a westerly course for about 1½ miles, thence northwesterly, following a grade line with a fall of 6 inches to the mile. It was originally made 50 feet wide near its head; it was 25 feet wide several miles below, and 50 feet wide in its lower sections. The narrow section was cut to the full width in 1892. It was planned to carry water 3 feet deep. A regulator is maintained in the head of the canal. This is a simple structure. Twelve light gates of 1-inch boards close the 4-foot openings between vertical posts which rise from a plank floor. The total width of the regulator between side walls is 50 feet. Its height is about 6 feet. It is weighted on top with a filling of earth. The canal supplies water to several thousand acres of land, most of which lies within the limit of overflow.

The canal is owned by an incorporated company, whose capital stock was fixed at $75,000, in 150 shares. The cost of the canal works has been about $5,000. The canal was constructed for the supply of water to lands owned by its stockholders and not for the sale of water. Each irrigator is required to own one share of stock for each quarter section of land (160 acres) which he wishes to irrigate. All distributing ditches are constructed by the irrigators, who take water from the main canal at the most convenient points.

Peoples Ditch.—This is a canal of the lower group whose head is on the south side of Kings River, about one-half mile above the head of Cole Slough. Kings River at this point flows in a broad, sandy bed to which there is a steep descent of about 15 feet from the level of the main valley plain on the south. The canal follows the margin of this plain for some distance southwesterly as it recedes from the river, and is gradually brought out upon the surface of the plain about 3 miles below its head. At about 4 miles below its head the distribution of its water to its branches commences. The diversion of water from the river is effected at low stages by means of a dam of brush and sand, which is annually repaired or renewed at considerable expense. Until within the last few years the inflow into the canal was controlled by

A. BRUSH DAM AT TIME OF HIGH WATER, PEOPLES DITCH.

B. REGULATOR IN PEOPLES DITCH, AS SEEN FROM ABOVE.

two regulators, one of which was within a quarter of a mile of the river bank, the other about 2 miles below. These were 24 feet in width and were of the ordinary culvert type with vertically sliding gates.

There is a new regulating gate now in service within several hundred yards of the head of the canal. This is a massive, well-built structure, 38 feet wide between side walls, which supports an earth fill about 2 feet thick, serving as a roadway over the canal. The space between side walls is subdivided by 10-by-10-inch posts into ten bays or openings, each of which is closed by means of a vertically sliding gate. Power is applied to the gate stems by means of a lever, the end of which engages between the teeth of a rack.

The canal has a fall of only about one-half foot in the first 2 miles of its course. The effective fall is increased somewhat by keeping the brush dam at a good height. The canal as originally constructed was 24 feet wide on the bottom, and was intended to carry 4 feet of water.

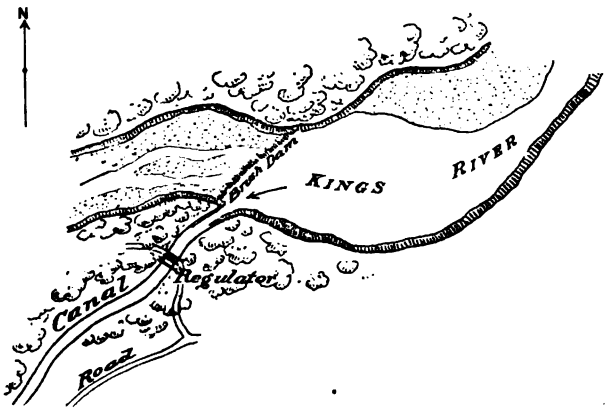


FIG. 18.—Head of Peoples Canal, on Kings River.

Its estimated capacity was about 220 second-feet. Below the second regulating gate the width of the canal increases to 30 feet, and the depth of water to be carried is only 3 feet. These dimensions are maintained for about 4 miles, still in a southwesterly direction and extending well into the northeastern extremity of that portion of the Kings River delta usually referred to as the Mussel Slough country. The canal has three principal branches: West Fork, which terminates near Grangeville; Middle Fork, which passes just to the westward of Hanford; and East Fork, which passes through the southern portion of Hanford and extends to points 4 miles farther south. The aggregate length of the main canal and its principal branches is about 37 miles. This canal was constructed by the Peoples Ditch Company in 1873 and the following years. The first notice of a claim to water was posted late in 1872. The company, formed by settlers who wanted water for their own lands, was finally incorporated in 1873. Its capital stock, originally fixed at $10,000, was soon increased to $35,000, and

later to $100,000. The first cost of the canal was about $50,000 to $60,000. The total cost of canal construction and annual expense account had reached $120,000 in 1881. About $4,000 to $6,000 are annually expended on the dam. The total annual expenditure for management, maintenance, and repairs is about $10,000.

Of the 100 shares into which the company's capital stock is divided about one-third have reverted to the corporation. The remaining shares are in the hands of irrigators, to whom water is delivered in amounts proportional to their holdings of stock. The stockholders are permitted to sell the water to which they are entitled and to ask for its delivery through any of the canal branches. Its use is not restricted to any particular tract of land. The delivery of water to irrigators is usually through gates 1 to 4 feet wide. It is discharged under pressure, the endeavor being to make amounts delivered proportional to stock which it represents, without any attempt at actual measurement. A canal superintendent, with necessary assistants, has charge of the delivery of water. Its equitable distribution depends largely on the judgment of the canal superintendent.

During the years 1883 and 1884 the experiment was tried of selling water to stockholders at $200 per share of stock per year; to those not holding stock an equivalent amount at $300 per year; but it did not prove satisfactory. All stockholders are assessed to meet the annual expenses. The area of land actually irrigated or benefited by the water of this canal is about 25,000 acres.

Mussel Slough Ditch.—This canal, which is now out of service, took its name from one of the delta channels of Kings River which has been utilized for the distribution of water. The canal, unlike the other canals of the Kings River delta, was constructed for speculative purposes. It was proposed to turn a large volume of water from the river into the slough and to derive a revenue from its sale to irrigators. The head of the canal was on the south side of Kings River, about 7 miles below the head of the Peoples Ditch. A narrow cut, the original bed width of which was about 10 feet, was made from that point southerly into and thence southwesterly along the upper portion of the channel of Mussel Slough. The bottom of this cut throughout a little more than a mile from its head was made level, being at an elevation a little below that of the river bed at the head of the canal. The upper portion of this cut, near the river, is over 14 feet in depth. As the canal leaves the river it grows wider, and at about 3 miles from its head the natural channel of Mussel Slough afforded ample capacity for its waters.

Mussel Slough and its principal branches, Sand Slough and Lone Oak Slough, have a general southwesterly course through the delta lands, passing to the west of Handford and extending to the high water line of Tulare Lake.

To what extent the canal has been in use in the last few years is not

known. It is now out of service, and was not in use for three years preceding 1886. Its head was closed with an embankment of earth in 1884, because at that time the river threatened to destroy the canal head gate and cause inundation of the upper and central portions of the delta.

The canal head gate or regulator was placed in the deepest portion of the cut, near the bank of the river. It was made 24 feet wide, the space between its walls being divided into a number of openings by vertical posts, between which gates slid vertically. The structure had the usual upper platform loaded with earth, making a roadway 20 feet wide. Its floor length was 40 feet. Sheet piling 8 feet deep was used on the upper floor line and for 12 feet under each wing; sheet piling was also driven 6 feet deep across the canal, on the middle line of the floor and at its lower edge.

Throughout the length of the natural channels utilized for the water of the Mussel Slough Ditch, check weirs or gates were constructed with which to hold the water surface at or above the surface of the ground. Irrigation was to be accomplished by subirrigation on a large scale. The charge for water ranged from 31¼ to 62½ cents per acre per year. There was little or no restriction as to the amount of water to be used by individual takers of water, and the principal duty of the canal superintendent seems to have been to prevent those from taking water who had no intention of paying for it.

The total cost of the canal works connected therewith was about $50,000 to $60,000.

This canal was constructed in 1875. Its promoters formed a corporation with a capital stock fixed at $500,000, divided into 10,000 shares, all of which remained in the hands of a few persons. The canal capacity was about 200 to 300 second-feet.

Last Chance Ditch.—One of the most important of the Kings River delta canals is the Last Chance Ditch, whose head is on the south side of the river about 2½ miles by river above Kingston. The course of the canal and its branches is southerly. It commands a district 3 to 4 miles wide, extending from near the river southerly to near the high-water line of Tulare Lake. Grangeville lies at the eastern border of this district and Armona well within it. Lands along its eastern border are commanded jointly by this canal and the Peoples Ditch. A natural cut through the south bank of the river, known as Leinberger Slough, has been utilized for the head of the canal. This slough is really one of the lower delta channels of the river. The canal is cut from its south bank about 150 feet from the river. The canal regulator is about 800 feet below its head. The water entering the head of the slough is divided, a portion flowing down the natural channel, the rest entering the head of the Last Chance Ditch. The canal has a bed width of 25 feet, and was designed for a 4-foot depth of water. Its course is a little west of south for 7 miles to a point half a mile west of

Grangeville, where it is divided into two principal branches. One of these has a southwesterly course and at the end of 3 miles drops its water into a natural channel which has a southerly course and connects with Mussel Slough. The other branch within a mile is again divided, forming a middle and an eastern branch, both of which extend far toward the south. These main branches were all made 16 feet wide on the bottom and were planned to carry water 2½ feet deep. The gradient of the canal is about 1 foot to the mile.

The original canal regulator, which was in service from 1874 to 1880, was made 18 feet wide between side walls and is reported to have cost $5,600. It was replaced by a second one, 20 feet wide, at a cost of $3,000. The removal of sand from the canals, which had been swept in by high waters during the period when there was no gate at the head of the canal, is said to have cost $3,000. The regulator is of the

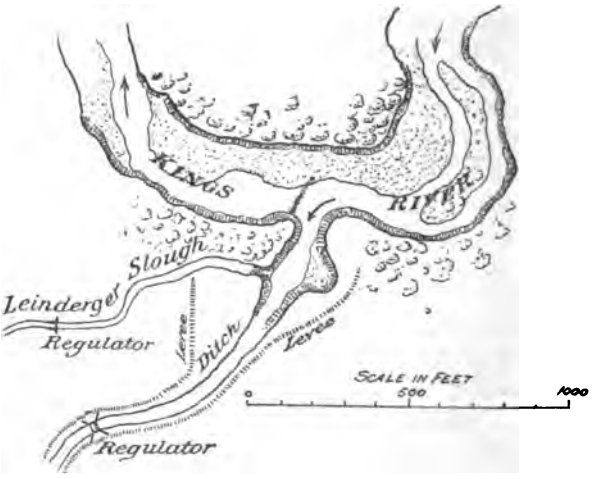


FIG. 19.—Head of Last Chance Ditch, on Kings River.

ordinary box type. From a floor 30 feet wide and 36 feet long (in the direction of the canal) side walls rise to a height of 14 feet. Between them are posts which support a platform or bridge that affords convenient access to the gates. The gateposts divide the space between side walls into six openings, each of which is closed with planking permanently from the top down to about 5 feet from the floor. The remaining open space is controlled by sliding gates having a long stem or standard to which power is applied by means of a lever engaging in the teeth of a rack. The gateposts are braced from below. Long wings extend diagonally into the canal banks above and below the gate. The upper ones are 14 feet high; the lower ones about 4 feet. Tongued and grooved 4-inch sheet piling was driven 10 feet deep along the upper edge of the floor and under the upper wings. Along both sides of the floor, across the canal at its lower end and well out under

A. LAST CHANCE CANAL REGULATOR, AS SEEN FROM UPPER SIDE

B. LAST CHANCE CANAL REGULATOR, AS SEEN FROM BELOW

the lower wings, 3-inch tongued and grooved sheet piling was driven 8 feet deep. Piles were driven to a depth of 12 feet under the braces to gateposts. Floor sills, piles, and main posts were 8 by 8 inches; side wall posts, 4 by 8 inches. The floor is of 3-inch planking, covered by 1-inch boards. Side walls are of 2-inch material, also covered with 1-inch boards. Back filling was selected sand. The bed of the canal below the gate was protected by a layer of brush, pinned down with stakes 6 to 8 feet long.

The Last Chance Ditch was constructed in 1873 and 1874 by a company known as the Last Chance Water Ditch Company, which was organized and incorporated by the farmers to whose lands it was to supply water. The original 30 shares into which a capital stock of $30,000 was divided were a few years later increased to 60 shares, and the capital stock was also doubled. Only about two-thirds of these shares are in the hands of stockholders. Until 1886 all operating and repair expenses, about $4,000 per year, were assessed upon the stockholders, and water was delivered to these without charge in proportion to amount of stock owned or controlled. Since that time water has been charged for at rates fixed annually, generally $1.50 per acre, in order to make actual users of water bear an increased portion of the canal expenses.

There has been no system of water measurement introduced. Water is delivered to irrigators through a great variety of gates; generally, however, through openings under pressure. A canal superintendent and an assistant have charge of its distribution. During the high-water period an attendant is kept constantly at the head gate. The canal ordinarily flows from the beginning of February to the end of July. About 20,000 acres of land are dependent upon it for water.

Lower Kings River Canal.—This is another south-side canal in the Kings River delta. Its head is about 6 miles below Kingston. Its course is southerly, and the district it commands lies just westward of that of Last Chance Ditch and has Lemoore in its center. The canal is cut southerly from the river, and at the end of its first mile reaches Leinberger Slough, into which its water is dropped. It is reclaimed from this slough less than half a mile below that point, and thence has a southerly course to within about 3 miles of Lemoore. Two principal branches, each about 16 feet wide on the bottom, extend toward the south from this point. Near the river the main canal crosses high-water sloughs fed by the over-bank flow from Kings River. These natural channels have been closed by dams on the lower or west side of the canal. Their water, together with other water escaping from Kings River above the head of this canal, is received by the canal and carried to Leinberger Slough. At the point where the canal leaves this slough a waste way 260 feet long is maintained, through which surplus waters are discharged. This is a very light timber structure, which is reported to have rendered good service. Some years ago it was proposed to

supplement it with a second waste gate, 200 feet long, nearer the head of the canal. The main canal regulator or head gate has been set close to the river bank. A secondary regulating gate is just below the Leinberger Slough waste gate. Each gate is about 40 feet wide between side walls. The head gate is arranged similarly to that described for the Last Chance Ditch. The main canal is about 40 feet wide. It was built on a very light grade. The bottom of the canal, commencing at the same elevation as the river bottom, was reported level throughout the first 5 miles of its course. The effective gradient slope of water surface when full is reported at 4 inches to the mile, with a 2½-foot depth at the forks of the canal. Work on this canal commenced in 1870. Twenty-seven persons joined in an agreement under which the canal was to be constructed, and which provided that each person was to bear a proportional part of "all expenses above" his "further boundary." It was at first made 18 feet wide on the bottom near its head, and 10 feet wide at 5 miles below its head. It was enlarged in 1873. The first head gate was constructed in 1872 and is reported to have had a width of 18 feet. It was washed out the following winter and was at once replaced by another, which was in use till 1876. After this second regulating gate was swept away the canal was operated without an upper gate until 1879, when the third regulator, 40 feet wide, was built, at a cost of about $3,000.

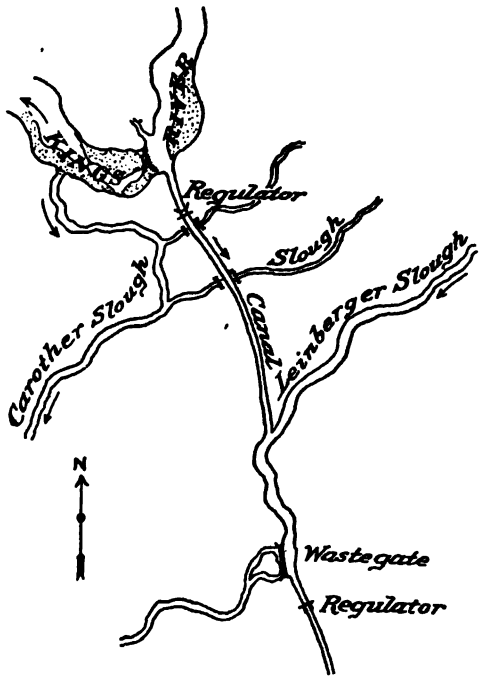


FIG. 20.—Upper section of Lower Kings River Canal.

The canal was built and is owned by those to whom it supplies water. Its owners, who had organized as a company, formed a corporation in 1873, with a capital stock fixed at $30,000, in 100 shares.

The water in the canal is supposed to be represented by those shares of stock which have been issued, which is a little more than one-half of the full number of shares of capital stock. It is sold by directors of the company, but only to the extent of the shares which have been issued. Each of these represents a proportional part of the flow of the canal until such part exceeds 144 miner's inches. Water in excess of

this amount is at the further disposal of the company. Stockholders are preferred purchasers of water to the extent of the shares owned by each, and provided the application for water is made preceding a fixed date. Each share of stock is supposed to represent sufficient water for 320 acres. The annual cost of canal management and repairs is about $1,500 to $2,000. The first cost of the canal was about $30,000. For a number of years after organization all expenses were assessed upon the stockholders, but, this proving unsatisfactory, the plan of selling water was introduced, with good result. The extent of irrigation from this canal may be noted at about 10,000 acres.

Rhoads Canal.—Lands to the west of Lemoore to the extent of 3,000 or 4,000 acres are dependent in large measure upon the flow of the Rhoads Canal for irrigation water. This canal in its upper section has the appearance of a natural high-water channel. From a point on the south side of Kings River about 1½ miles below the head of the Lower Kings River Canal, this channel has a southwesterly course for 2 miles to Carother Slough. It is known as Wrights Cut, and is claimed to be the enlargement of a small ditch constructed many years ago. The Rhoads Canal is carried southward from the termination of this cut at Carother Slough about 7 miles. It has a bottom width of about 16 feet and carries water about 2 feet deep. Water is taken from Carother Slough so long as the slough has a sufficient flow; thereafter a little work is done at the head of Wrights Cut to turn more water from the river into the canal.

The canal is reported to have been in use since 1868. It replaced a small ditch, about 5 feet wide, which had been in use some years before. The canal belongs to a number of farmers, who by mutual agreement apportion its water and expense of maintenance among themselves. There is no regulator at the head of the canal. Water is taken by each irrigator as he may require it. No water is sold, and all contributions toward expenses of maintenance are voluntary, as there are no means of enforcing their payment.

There are times when much more water flows in Wrights Cut than can be carried by the lower sections of the canal. The surplus reaches Green Slough through Carother Slough, thence Esrey Slough and other natural channels, and is finally reclaimed for the irrigation of lands about 4 miles southwest of Lemoore.

Jacobs Canal.—This is a private high-water canal, constructed about ten years ago for the benefit of lands along the northern margin of Tulare Lake, below the lake's high-water line. Its head is about 6 miles southwest of Lemoore.

SUNSET IRRIGATION DISTRICT.

As the construction of the works for this district has not commenced, a brief reference to the district and its proposed source of supply will suffice. The district covers the lowest portion of the west side plain of San Joaquin Valley, extending northward from the southern limit

of Tulare Lake about 70 miles, to within 3 miles of Las Juntas, the point where Fresno Slough unites with San Joaquin River. Its width ranges from 1 to 12 miles and its area is about 363,500 acres. The district organization was completed in March, 1891. After estimates of the cost of works necessary for its irrigation were made, a bond issue of $2,000,000 was voted. Of this bond issue $250,000 were paid for water rights, reservoir site, and rights of way.

The plan of irrigation involves the construction of a large reservoir in the vicinity of Summit Lake, which is to be formed by the construction of two embankments of earth, each crossing the valley trough from east to west. Water is to be supplied to this reservoir from Kings River by way of Cole Slough, the enlarged Grant Canal (which is to be used in common with the owners of the Grant), and a canal extension to be carried from near the lower end of the Grant Canal in a direction a little south of west across the North Fork of Kings River to the reservoir site. From the reservoir there is to be a canal northward and a second one southward, both supplied with water by gravity flow from the reservoir. In addition to these two low-level canals there are to be eight other canals, four northward and four southward, each 11 feet higher than the one next below, and each to be supplied with water by means of centrifugal pumps arranged in four pumping stations.

The specifications drawn for this work do not indicate how the seventeen pumps that are prescribed are to be apportioned to the several pumping stations. The pumps are each to have a capacity of 100 second-feet raised 11 feet. The district canals are to be of sufficient size and length to carry water to all parts of the district. The requirements concerning canal dimensions are not made specific; they are to be suitable to the service required, which, it appears, remains to be determined as work progresses. The aggregate length of the proposed district canals is estimated at 500 miles. The contract for the construction of the canal system complete, including the necessary pumps, engines, and boilers, has been let for $1,500,000, and the same person who has taken this contract is also the purchaser of the bonds of the district. It is distinctly expressed in the contract that in case the bonds are not taken the contract may, at the option of the district directors, be set aside. The contract was made several years ago, and was conditioned upon a decision by the Supreme Court of the United States sustaining the irrigation-district law. This having been rendered, it is understood that the contractor has now declared his readiness to proceed with actual construction work.

THE FRESNO PLAINS.

DESCRIPTION.

The main canals which divert water from the north side of Kings River at or near the upper end of Centerville Bottoms and command that portion of the San Joaquin Valley plain in the vicinity of Fresno, Selma, and Kingsburg may be designated the Fresno group of canals. These canals are the Kings River & Fresno Canal, the Fresno Canal, the Fowler Switch Canal, and the Centerville & Kingsburg Canal, all of which have already been described. Their branches extend throughout an area of nearly 400 square miles, which before canal construction was a treeless, sandy plain. It was almost devoid of natural water courses. The few creeks whose periodical flow reached the eastern border of the plain to the north of Kings River were soon lost, and there was no sign of a channel beyond their "sinks." The natural water courses in the eastern portion of the district under consideration, in their order northward from Kings River, were Burns Slough, Kip (Lone Tree) Slough, Mud Slough, Mud Creek, Fancher (Fanshaw) Creek, Red Bank Creek, Frolic Creek, and Big Creek. Of these, the first three lie to the south of the point of the mountain which with gentle slope extends westward on the north side of Kings River to a point 2 miles north of Centerville. Burns Slough is a tributary of Kip Slough. The sink of Fancher Creek, now a fine vineyard, is about 4 miles east of Fresno. The waters of Red Bank and Frolic creeks, after uniting in one channel, spread and disappear 6 miles east of Fresno, near where Temperance Colony has been established. The sink of Big Creek is several miles to the northwest of Fresno.

Some of the channels of these creeks have been made part of the canal system. Portions of Burns Slough and Big Creek are utilized for water of the Kings River & Fresno Canal. Other portions of Burns Slough, Kip Slough, Mud Slough, Mud Creek, and Fancher Creek are now the main channel of the Fresno Canal. Lone Tree Creek is an important distributary of the water of the Fresno Canal. By the utilization of these natural water courses the canals are made the recipients of the drainage water from the foothills, and are, at time of considerable rainfall, taxed beyond their capacity, and have repeatedly in the last few years inundated parts of Fresno and vicinity. A proper drainage system in this locality is now recognized as a necessity, and no doubt will be planned and executed in the near future. The general slope of the Fresno irrigated region is from northeast to southwest, at the rate of 5 to about 7 feet to the mile. The surface of the country for the most part is very smooth, though broad belts of hog-wallow or knolly ground are occasionally found. The knolls of these hog-wallow belts are generally 1 to 2 feet in height, rarely as high as 3 or 4 feet. The knolls are close together, and diameters at the

base of from 20 to 40 feet are most common. Where they occur the expense of preparing land for irrigation is increased. Except where unusually high they do not interfere seriously with ordinary farming operations when land is not irrigated. They often indicate land of inferior quality, hardpan being frequently found beneath a shallow layer of surface soil.

Near Centerville the soil of the upland is a red sandy loam, resting on a yellow clay hardpan, which is usually at 4 to 6 feet below the surface. Hardpan is not continuous; it disappears frequently at about one-half mile from the margin of the upland, where the surface soil becomes lighter and more sandy. At depths of 10 feet or more beds of cobble and gravel are found, which in proximity to the low river bottoms afford thorough underdrainage to these lands. The soil is very productive. Ground water is at 12 to 15 feet below the surface.

Westward from Centerville toward Fresno the soil of the plains is a loamy sand. This generally rests on a firm clay hardpan, which is sometimes impregnated with sand. Soil is from 1 to 3 feet deep. At the sinks of the several creeks near Fresno the soil is a deep, heavy, red loam, baking on the surface after being wet. Where a hardpan substratum is encountered at all it is at 10 to 30 feet below the surface. Westward from the immediate vicinity of the sinks of the creeks the soil is a loamy sand, several feet deep, resting on a firm clay hardpan. The soil far toward the southwest merges into the sandy soils of the alkali belt which skirts the edge of Fresno Swamp, and these in turn are succeeded by the rich peaty alluvium of the swamp lands. To the south of Fresno the sandy soil of Fresno and Central California colonies changes to the light so-called ash of Washington Colony. The hardpan dips farther below the surface toward the south, and there are points in the latter colony where it has disappeared altogether. In the southern and southeastern portion of the region commanded by this canal system sand predominates. The surface of the country is comparatively smooth, though occasionally crossed by low sand ridges. Firm hardpan, partaking of the nature of cemented sand, immediately below the surface soil is rarely found. It occurs most frequently where the surface presents the peculiar hog-wallow appearance.

The rainfall in the region commanded by the Fresno Canal system is greatest near the base of the foothills. It decreases from there toward the west. At Centerville the average fall of rain is about 16 inches, while at Fresno and Kingsburg it is 9 inches. The average fall at Firebaugh, 30 miles to the west, in the trough of the valley, is about two-thirds of that at Fresno. For the irrigated region near Fresno the mean annual fall of rain may be noted at about 9 to 10 inches. When this amount of rain falls at the proper time it is sufficient to insure fair crops of grain. Throughout a large part of the region rainfall is relied upon to produce a crop, and irrigation of grain is resorted to only when an unusually dry spring threatens the destruction of a growing crop. The products which can not be raised without irrigation are alfalfa,

grapes, fruits of all kinds, including citrus fruits, corn, melons, etc. Two of the canals irrigating lands near Fresno have a perennial flow; the others divert water only during medium and high stages of the river, generally from January to August, inclusive. The aggregate capacity of the four canals already enumerated is about 1,550 second-feet. None of them, however, flow for long periods at their maximum capacity. The demand for water is, fortunately, greatest at the time when the flow of the river is greatest, during spring and the early part of summer.

THE CANAL SYSTEM.

All of the canals of the Fresno system take water from Kings River above Centerville. Each of them is out upon the upland before passing that village. Such duplication of canal work seems unnecessary.

Each of these canals was constructed for the purpose of supplying water to some particular point or place of use; thus, the Fresno Canal to irrigate lands in the immediate vicinity of Fresno, the Kings River & Fresno Canal to irrigate a strip of land just north of the Fresno Canal, the Centerville & Kingsburg Canal to irrigate lands near Selma, and the Fowler Switch Canal to supply water to the vicinity of Fowler and lands westward from that point. By reason of such special requirement in each case, each canal received an alignment as direct as possible from the proposed source of water to the point of delivery. The main canals were therefore constructed without attempt to hold them to any uniform grade. They have alignments in the direction of the greatest fall of the country, and generally, when their grade is excessive, check weirs are used to prevent erosion. The flow of water in the Kings River & Fresno Canal and in the Centerville & Kingsburg Canal is thus regulated. The regulation in the case of the Fresno and the Fowler Switch canals is only partial. The water of the former of these canals in Fancher Creek is generally 8 to 15 feet below the surface of the ground, its elevation being uncontrolled by structures.

The Fowler Switch Canal was constructed on a very irregular grade line. Its grade, when possible, was placed at 1.92 feet to the mile, which was established as the minimum gradient. At some points, however, the grade was no less than 12 feet to the mile for short distances. The dimensions of the canal were calculated on a basis of a fall of 1.92 feet to the mile, and were not modified for heavier grades. Consequently, canal dimensions where this grade was exceeded are excessive. The canal was originally constructed without structures, either for the regulation of its flow or to facilitate diversion. Rapid erosion at once commenced where the canal bed was not in very firm material, and after a short experience a limited number of check weirs were put into it at the points where most required. The structures in this and in the other canals of the district are very light timber affairs, but generally well adapted for the purpose which they are to serve.

In view of the fact that the irrigation of this region has in the past

caused a rise of the ground-water plane, and that it will continue to influence its elevation, the question whether water has been or is being lost by the apparent duplication of canals remains an open one. Certain it is that were all water drawn from the river in one main canal it would still be necessary for branch canals to extend to every portion of the irrigated region. The ground water would be expected to rise equally as rapidly as at present, and the only marked saving of water would result from the exposure of a decreased surface area of flowing water to evaporation, and, in this special case, from a possible reduction of the flow of water from the main canal through subsoils back into Centerville Bottoms.

LOSS OF WATER BY EVAPORATION AND SEEPAGE.

The loss by evaporation, when expressed in second-feet, is small for any of the canals of the Fresno system when compared with their capacity or with the total loss by infiltration into subsoils. The State engineering department made experiments to determine the rate of evaporation in this vicinity. The observations were extended through a four-year period at Kingsburg.[1] The greatest total monthly evaporation during the four years 1881 to 1885 occurred in August, 1883. The amount of water evaporated in that month from an open sheet of water was equivalent to a depth of 0.945 foot. At this extreme rate per month the loss by evaporation from the surface of the Fresno Canal throughout the 24.5 miles of its length, if the canal be considered 60 feet in average width (which allows ample margin for wet banks), would have been equivalent to a continuous flow of 2.8 second-feet.

To determine the amount of water which sinks into the subsoils from the canals of this region, measurements of their flow were made in the summer of 1882 by the writer, then assistant State engineer. The results will be found on pages 76 and 77, in tabular form. For the better understanding of the results presented in the tables it is necessary to refer briefly to the character of the several canals and ditches whose flow was at that time measured.

The Kings River & Fresno Canal at its head cuts at once into the upland to the north of Centerville Bottoms. For a long distance it is nearly parallel and sometimes very close to the Fresno Canal, with a water surface at a higher elevation than that of the latter. At many points the canal carries its water above the surface of the adjacent plain. Ponds and swamps were kept full of water which the canal lost by percolation. The canal, throughout the last few miles of its first 12, lies in a good channel with hardpan bed. The loss of water in the upper 12 miles was at the rate of 3.77 second-feet per mile. In 1882 the section of the canal below Red Bank Creek was poorly maintained. Water was allowed to spread out in ponds, and a former channel lying parallel to the present canal, and generally very close to it, frequently carried part of the canal waters. No lands on this section of the canal were

[1] See Physical Data and Statistics, Wm. Ham. Hall, State Engineer of California, p. 379.

irrigated close by the main canal. Ground water was at 20 feet or more. An indurated clay hardpan lies below the surface soil along this portion of the canal. Here, throughout 4.76 miles in length of the canal, the average loss by percolation was 3.45 second-feet per mile, a trifle less than in the 12 miles above. In the next section of the canal copious irrigation of lands close by the canal, particularly on its south side, had been practiced for several years preceding the experiments. The soil is a light sandy loam, with ground water at 7 to 14 feet below the surface. The water surface of the canal was carried at about the elevation of the ground. The land is very smooth; no high levees are necessary to hold water in its channel. The canal is of uniform dimensions and character, and is better maintained than at points above. These circumstances all combined to reduce the loss by percolation, which, for 3.55 miles, was found to be 1.25 second-feet per mile. Evaporation at the maximum rate above noted would have caused a total loss from the 20 miles of the main Kings River & Fresno Canal under consideration of a little more than 1 second-foot, equivalent to a loss of 0.04 second-foot per mile in length of the canal.

The water of the Fresno Canal flows in natural channels throughout nearly all of the first 19 miles of its course. It lies in Centerville Bottoms for a mile, then, after passing through Long Cut, is carried along sloughs and depressions, frequently with a levee only on one bank. Willows, reeds, and grasses grow in the water and on the banks of the canal in that locality. In Mud Creek and Fancher Creek the canal water flows in the bottom of a narrow, deep channel. At the time of making the experiments, in June, 1882, there were 95.51 second-feet lost from the canal in the first 11¼ miles of its course below the point where it leaves the river bottoms. The loss of water was at the rate of 8.49 second-feet per mile.

The ground-water plane was quite close to the surface of the ground near the Fresno Canal in its next section, from the Limbaugh dam (the head of the Fresno Mill Ditch) to the head of the Washington Colony branch, a distance of 7 miles, throughout which the total loss by percolation was only 5.20 second-feet, or 0.74 second-foot per mile. Here the depth to ground water ranged only from 4 to 10 feet, and the surface soil and the subsoils were kept saturated by water diverted for irrigation. The canal lies in a natural channel. Its water surface is generally 2 to 4 feet below the surface of the ground. From the head of the Washington Colony branch the main canal flows for 4 miles in an artificial channel of uniform dimensions. Water is carried at about the elevation of the surface of the ground. The lands adjacent to this part of the Fresno Canal were practically unirrigated in 1882. Ground water was not so near the surface as in the preceding canal section. The total loss in this section of the main canal was found to be 3.81 second-feet, or 0.95 second foot per mile.

The Centerville & Kingsburg Canal, for about 8 miles after it is out upon the surface of the upland, has a course nearly parallel to the

edge of the bluff from upland to the river bottoms, and less than half a mile distant from it. For several miles the canal is within several hundred yards of the edge of the descent to the bottoms, which lie 20 to 30 feet below the surface of the upland. This location in porous soils and subsoils causes great loss of water by percolation. Nearly 86 second-feet were lost by the canal in less than 6 miles, and in its seventh mile the canal lost 52 second-feet. This last result is based on measurements of the flow of water over two weirs 1 mile apart, apparently in good condition. The average loss per mile from the canal in the 5½ miles of the upper section examined was 15.63 second-feet.

Loss of water from the Kings River & Fresno Canal.

Name of canal or ditch, and locality.	Distance below head of canal, in miles.	Discharge, in second-feet.		Loss between stations, in second-feet.	
		Main canal.	Diverted.	Total.	Per mile.
K. R. & F. C., one-half mile below head	0.50	133.83	.....		
Burns Ditch	1.00	.....	0.25		
Hansen Ditch	4.00	.....	3.23		
Fancher Creek (wastage)	8.00	.....	.30		
Ditch on south side	8.00	.....	4.05	43.36	3.77
Do	9.00	.....	.05		
K. R. & F. C. at Hawkins Weir	9.00	[1]78.18	.....		
Wastage	.....	.....	.15		
Ditch on south side	11.50	.....	2.04		
K. R. & F. C. in Red Bank Creek Flume	12.00	80.40	.....		
Dog Creek (wastage)	13.25	.....	.15		
Ditch on north side	16.00	.....	3.36	16.50	3.48
Eggers Ditch	16.75	.....	4.67		
K. R. & F. C. at Eggers Weir	16.75	55.72	.....		
K. R. & F. C., west line of section 17	17.75	[1]49.56	.....		
Ditch on south side	17.80	.....	3.08		
Scandinavian Colony Ditch	18.25	.....	3.86		
K. R. & F. C. at upper Scand. Col. Weir	18.25	[1]36.74	.....		
Scandinavian Colony Ditch	18.35	.....	1.46		
Do	18.50	.....	2.42		
Do	18.60	.....	1.00	4.44	1.25
Do	18.70	.....	2.39		
Do	18.80	.....	14.50		
K. R. & F. C., lower Scand. Col. Weir	19.00	[1]25.51	.....		
Big Creek (wastage)	19.25	.....	1.50		
Wastage	.....	.....	.20		
Ditch on north side	19.75	.....	.43		
Cooper & Helm Ditch	20.25	.....	8.71		
K. R. & F. C. at Cooper Weir	20.30	11.73	.....		

[1] Approximate.

Loss of water from the Fresno Canal.

Name of canal or ditch, and locality.	Distance below head of canal, in miles.	Discharge, in second-feet.		Loss between stations, in second-feet.	
		Main canal.	Diverted.	Total.	Per mile.
Fresno Canal at Road Bridge	1.25	381.00	.....		
Centerville Branch	1.75	.....	17.80		
Lone Tree Branch	3.25	.....	69.39	95.51	8.49
Ditch on south side	5.00	.....	.50		
Limbaugh Dam Ditch	12.50	.....	58.72		
Fresno Canal at Limbaugh Dam	12.50	139.08	.....		
Briggs Canal	14.00	.....	.30		
Eisen Canal	14.00	.....	14.09		
Fresno Canal at Hobler Dam	14.00	107.88	.....		
Easterby Ditch	17.25	.....	5.60	5.20	.74
Malters Ditch (north)	19.00	.....	6.30		
Malters Ditch (central)	19.00	.....	1.69		
Washington Colony Branch	19.50	.....	45.50		
Fresno Canal at head of Wash. Col. Branch	19.50	60.40	.....		
Fresno Colony Canal	23.50	.....	14.15	3.81	.95
North Central Colony Canal	23.50	.....	13.88		
Main Central Colony Canal	23.50	28.16	.....		

Loss of water from the Centerville & Kingsburg Canal.

C. & K. Canal, one-half mile below head	0.50	346.00	.....		
Ditch on west side	5.50	.....	5.06	85.94	15.63
Do	5.75	.....	4.00		
C. & K. Canal at weir, in sec. 23	6.00	251.00	.....		
Garfield Canal	7.00	.....	26.65	52.35	52.35
C. & K. Canal at weir, in sec. 26	7.00	172.00	.....		

Other examples of the loss of water from smaller ditches by percolation into the subsoil are the following:

On June 21, 1882, water was being used for the irrigation of a vineyard in Scandinavian Colony. The water was diverted from the main supply canal into a small ditch about 2 feet wide. It was conducted past alfalfa fields and vineyard lands a distance of one-half mile to the point where it was being used for irrigation. The soil crossed by the ditch is a sandy loam, with ground water at 8 feet below the surface. Water was measured at the point of diversion and at the point of delivery in exactly the same way, over small overfall weirs. The amount diverted was 1.70 second-feet, and the loss in transit 0.79 second-foot.

On June 14, 1882, the orchard of the Gould Ranch north of Fresno was being irrigated. The water used for this purpose was flowing in a ditch having an average width of 3 feet. One mile above the point where the water was being used the discharge of the ditch was 2.41 second-feet. The loss by percolation before reaching the point of delivery was 1.42 second-feet. Shade trees were growing along portions of the ditch, and its banks were overgrown with grass. The ditch had been in use several years. The soil through which it flows is a sandy loam 5 to 8 feet deep.

On June 26, 1882, a ditch which leaves the Fresno Canal at a point about 4 miles east of Fresno was carrying 5.60 second-feet near its head. One mile below it was receiving 0.03 second-foot, and at other points 0.64 second-foot; its flow 4 miles below its head was only 1.89 second-feet; it had lost 4.38 second-feet. This ditch has an average width of about 8 feet. It carried its water at or a trifle above the level of the ground's surface.

EFFECT OF IRRIGATION ON THE WATER TABLE.

In no other irrigated region in California is the effect of irrigation on the elevation of the water table so plainly apparent as in the vicinity of Fresno. Here, notwithstanding the 6 feet per mile slope of the surface of the country, the subsoils have been and are being gradually saturated with water. When irrigation commenced the loss of water from canals in transit to lands to be irrigated was very great, and after reaching its destination it was found that frequently enough water was put upon the surface of individual small tracts of land to have covered them to an average depth of 15 to 20 feet in a season. Most of this water found its way into subsoils, together with the direct loss of water from the canals. When the first wells were dug at Centerville water was found at about 20 feet. It is now at 10 to 15 feet below the surface, and will probably not rise much higher on account of ample drainage of subsoils and a comparatively free subsurface flow toward the low river bottoms.

Along Fancher Creek, where the creek is used as a canal, ground water was formerly at 50 to 75 feet below the surface; it is now at 12 to 20 feet along the upper portion of the creek, and still nearer the surface near the former sink of the creek, about 4 miles east of Fresno. In the Eisen vineyard, 5 miles east of Fresno, ground water is at 4 to 6 feet below the surface, and drain ditches have been constructed to prevent a further rise. Ground water is found at 4 feet below the surface in many parts of Temperance Colony, Nevada Colony, and Fresno and Central colonies. Throughout a considerable area near Fresno its surface is nowhere more than 16 feet below ground, though before irrigation commenced depth to water was 60 feet. Cellars which were in use until 1884 in Fresno have been condemned because ground water made its appearance in them. Near Selma and Kingsburg

ground water was formerly found at about 30 feet. It is now at about 15 feet. The so-called "Sand Hollow," which is a depression 100 yards to one-fourth of a mile wide, 12 miles long, and about 16 feet deep, having a southerly course and passing about midway between Selma and Kingsburg, was formerly as dry as the surrounding plain. About 1880 the soil in its bed was found to require less moisture to produce crops than the adjacent plain; in 1885 water appeared at the lowest points of the bed, and in June of that year it had risen to the heads of ripening grain. Spots of black alkali now mar its bed and sides, which before were a light sand, apparently free from any excess of alkaline salts.

Near Sanders and at points eastward from there toward Kings River ground water was at 50 to 60 feet before irrigation commenced; it is now at 20 to 30 feet. Here, as in the case of Centerville, proximity to the river, which lies 60 feet below the surface of the plain, may interfere with a much greater rise of the ground-water plane.

In connection with this change in the elevation of the ground-water plane, it must be remembered that the effect of irrigation extends far beyond the points now under ditch. Owing to the slope of its surface and consequent hydrostatic pressure, ground water has a slow but certain motion westward through pervious subsoils of the Fresno region, and may therefore ultimately contribute more or less toward the flow of Fresno Slough and San Joaquin River.

METHODS OF IRRIGATING AND DUTY OF WATER.

At the time irrigation commenced near Fresno the soils and subsoils were dry; depth to ground water was 30 to 60 feet. The ground was porous, generally sandy, sometimes very hard on the surface. When wet it was converted into a bog. Water passed through it readily into the lower strata. Thorough wetting compacted the soil, and it was less liable to conversion into slush after the first and second wettings than before. It settled, as a result of the first wetting, about 8 inches to 1 foot, on an average. Sometimes the full supply of a ditch would flow for hours into a hole formed by the breaking in of the surface. Cavities 20 feet in diameter and 6 to 10 feet deep were occasionally formed in this way, and had to be refilled after the first wetting. The stability of buildings was in danger when water was first brought near them. It is not surprising, under these circumstances, that when irrigation commenced in this region sometimes enough water was run on small areas at one irrigation to have covered them 5 feet in depth, and that enough water was delivered to some of the 20-acre colony lots south of Fresno to have covered them to an average depth of 20 feet. After irrigation was practiced for a time the soils became more compact, absorbed water less rapidly, and a smaller amount of water passed into subsoils. At present the ground water near Fresno is so near the surface that the roots of alfalfa, vines, and trees readily penetrate to

it and soils are kept moist by the water rising from below. Surface wetting has become unnecessary in many sections.

Where land is held in tracts of 20 to 40 acres, as in the colonies near Fresno, the subdivisions of alfalfa, vineyard, orchard, etc., are small. The individual irrigator has but a small area of soil to moisten and, because many irrigators in his neighborhood necessarily require water at the same time, he can probably command but a small flow with which to accomplish his irrigation; consequently he devotes more than ordinary care to the preparation of his land, and if the duty of water is not so high on his lands as it ought to be the good will of the irrigator is not at fault.

The subdivision of land holdings into small tracts and the greedy absorption of water at the outset by the dry soil of the Fresno plains were the prime factors which have controlled methods of irrigation. That which most frequently found favor was flooding in small checks whose surface had been made perfectly level, it being extremely desirable to quickly cover the whole surface to be wet with a thin sheet of water. Drainage appeared unnecessary, as all surplus water delivered into a check rapidly sank into the ground.

The area of these level checks generally ranges from one-quarter of an acre to 2 acres. They are nearly always made rectangular. In alfalfa fields the levees inclosing them are often made so flat and low that farming implements can pass over them. Their position is adapted to the configuration of the country, in order to make the work of leveling as small as possible. Irrigation ditches are so arranged that there is an inlet from a ditch into each check. No drains are provided. All surplus water entering a check is allowed to sink into the soil. The cost of preparing land in this way has been variously stated by the irrigators at from $15 to $50 per acre.

Water is admitted into the several checks through small gates, or occasionally through small sluice boxes, generally constructed of 1-inch redwood. Water in the irrigating ditches is controlled by means of small gates closed by loose boards moving easily in vertical grooves. Sometimes a notched board is set across the ditch, so arranged that the notch can be closed by means of a board upon either side of the notch.

The system of flooding in checks formed by contour levees, which has found much favor with Kern River irrigators, is in use only for the irrigation of large tracts of alfalfa, but where used in the vicinity of Fresno the area of the checks is kept small, rarely exceeding in any case 3 or 4 acres, whereas in the Kern River country the area of a single check frequently exceeds 10 acres. Contour levees are lower for checks of smaller area. The expense of ground preparation is greater, but irrigation is more economical, as with small checks much time and water are saved. The contour levees usually follow closely 4-to-6-inch contour lines. Soils are so porous that irrigation in each check is complete when water has been made to cover its whole area,

otherwise there is no deviation from the ordinary practice of irrigation in contour checks.

A third system of flooding is sometimes practiced, though it has not found general favor. It is that of flooding the surface with water from small ditches which are carried along the tops of ridges, or very nearly on contour lines. The water of these is made to overflow one or both banks, and as the thin sheet of water flows over the surface it is guided and to some extent controlled by attendants. Unless the ground is very knolly this system requires but little preparation, except the construction of the irrigating ditches, but the application of water is attended with much greater expense than under the preceding systems. It has been in use for trees and vines as well as for alfalfa.

The furrow method of irrigation is growing in favor. It is practiced in many ways, according to conditions of surface slope and crops to be irrigated. When water is to be supplied to the surface of grain land in large areas it is generally done by the furrow method. Distributing ditches supply water to plow furrows or to small temporary ditches which are placed so close together that water can readily permeate the surface soil, particularly that portion of it which has been loosened by the plow. The furrows may be run on or near contour lines; they may be run in the direction of the greatest slope of the ground's surface, or they may be run in parallel lines between the rows of trees, vines, corn, vegetables, etc. Sometimes this system of irrigation is practiced in level checks for trees and vines in preference to the plan of flooding the whole surface.

When grain land is to be irrigated by the furrow method the furrows are drawn 8 to 12 feet apart in the direction of the greatest slope of the ground, unless this be so great that water flowing in the furrows would cause erosion. Should this be the case they are drawn obliquely to the greatest slope. The irrigating ditches are located on the ridges, if there be any, or on grade at intervals of one-half to one-quarter mile from near the upper edge of the tract to be irrigated, and about parallel with it, to near the lower edge of the tract. The irrigation commences at the highest point of the field from the upper ditch. Water is admitted into a number of furrows, in which it flows until moisture reaches the next ditch; it is then turned into other furrows, until all the furrows between the first and second ditches have been wet. Hereupon the water is turned into the second ditch, another set of furrows is wet, and so on until irrigation is complete.

This system of wetting from furrows is practiced for grain land as well before seeding as when a growing crop is to be irrigated. In the latter case the refilling of small ditches and furrows that would otherwise interfere with harvesting operations adds somewhat to the expense of irrigating.

Under the furrow system of irrigating each attendant ordinarily controls about 1½ to 2 second-feet, and water is generally turned off at

night, owing to the difficulty of controlling it in the dark. On the sandy soil of the region covered by the Centerville & Kingsburg Canal, where this method of applying water has found more favor than elsewhere, irrigation progresses at the rate of about 2 acres per day for each second-foot of water. Each irrigation is there equivalent to an average depth of one-half foot of water over all the land irrigated. It should be stated, however, that very little wheat land is regularly irrigated on the Fresno plains at points where water must be applied to the surface soil. Irrigation is rather a last resort to save a growing crop which the farmer hoped would mature without irrigation. For the regular irrigation of grain land it is customary to rely upon one irrigation in the fall of the year before plowing. The moisture then absorbed is sufficient to supplement the scant rainfall and make a good harvest reasonably certain.

The lack of natural deep-cut drainage lines through the lands of the Fresno district has already been alluded to. Their absence has made possible the remarkable filling of the subsoils with water and the rising of the ground water to within a few feet of the surface. Whenever ground water is brought so near the surface that capillary attraction and the hygroscopic properties of soil cause water to rise sufficiently high to moisten the surface layers of soil, other methods of supplying moisture become unnecessary. Crops are irrigated if ground water is permanently held at this height, or if it is so frequently raised to this height that the soils under cultivation receive all the moisture required from below. Where water is thus brought within reach of plant roots the system of irrigation is locally often referred to as "irrigation by percolation." It becomes a system when, as in the Mussel Slough country south of Kings River, the canals at the proper season supply the requisite amount of moisture to the cultivated tracts without burdening them with an injurious surplus during the rest of the year.

By the rising of the ground-water plane near Fresno large tracts of land have been permanently moistened. Some are very thoroughly subirrigated, and in many instances injuriously so. Relief must be sought in some localities either by drainage or by proper regulation of the supply of water to the district, whereby the elevation of the water table may be controlled.

Near the Fresno Canal, about 7 miles northeast of Fresno, lands were already too moist in 1882 to permit farming operations. Drain ditches 4 feet deep were then in use in Temperance Colony to drain the surface soil. In 1885 drain ditches 4 to 6 feet deep were in use in the Eisen vineyard, 5 miles east of Fresno, to keep ground water at least 4 feet below the surface of the ground. Parts of the town of Fresno, parts of Fresno and Central colonies, and lands to the north and west of Fresno may be cited as other instances of the too close proximity of ground water to the surface.

Some reference has already been made to the time of irrigating cer-

tain kinds of crops and the amount of irrigation accomplished by a stated amount of water. Some further illustration of the time when water is required for different products, and of the quantity absorbed by soils under the various conditions of irrigation in this vicinity, may not be out of place here.

Alfalfa, except when the water table is so near the surface that soil is kept moist from below during the entire growing season of this plant, is almost invariably irrigated once for each crop of hay cut. The first irrigation is early in spring and the first hay is cut in May; the succeeding ones at intervals of about five or six weeks. The number of crops cut is generally four; the average yield per acre is 1 to 1½ tons per cutting. Irrigations subsequent to the first of the season are given either before or just after the cutting of each crop. It is said in favor of irrigation before cutting (about one week or ten days) that then the ground's surface is shaded, it does not bake so hard in drying, and the new growth of alfalfa is better able to withstand the heat of the sun than if subjected to an irrigation after the hay is cured. But, whenever alfalfa is irrigated before cutting, in checks not perfectly level, water in some parts of these stands too long about the plant, too much of the plant is submerged, and the quality of the hay is impaired.

Where the ground water is so close to the surface that it supplies sufficient moisture to alfalfa land, occasional floodings are necessary to drown gophers.

Trees and vines were, until the last few years, very copiously and very frequently irrigated in this region. Trees were generally watered three or four times during the spring and summer; vines sometimes every two to three weeks. The water during the first years of irrigation near Fresno was, almost without exception, applied to the surface, and the result was that the roots of trees and vines frequently failed to penetrate into the subsoils, entailing evils which could not easily be corrected and which were particularly apparent in the quality of the product. The lesson was not quickly learned, but there has been decided improvement. Less moisture is supplied to the surface soils and greater care is taken to keep the surface well cultivated. Capillary attraction is thus interrupted at the depth to which the plow has penetrated, less moisture is brought into direct contact with the air, evaporation is consequently reduced, and plants are enabled to get the greatest possible benefit from the moisture already in the soil. Some examples from actual experience may illustrate how water is here used.

On June 16 to 17, 1882, 5 acres of alfalfa in small checks thoroughly leveled were irrigated in eight hours, from 6 p. m. to 2 a. m., in Central California Colony. The head of water used was 0.84 second-foot. The amount of water absorbed by the soil was equivalent to a depth of 0.11 foot over the entire 5 acres.

On the 17th of June, 1882, in Central California Colony, a supply of 2.26 second-feet was divided into four parts and each admitted into an

alfalfa check having an area of 1¼ acres. The irrigation of the alfalfa commenced at 6 a. m., and at 4 p. m. the water had been made to cover the entire area of each check. Alfalfa was being irrigated before cutting. The checks were level and no water was drawn off. The total amount supplied was equivalent to a depth over all of 0.37 foot. The soil was sandy loam; hardpan was 6 feet below the surface; ground water at about 12 feet. Less water would have been required if the whole stream had been admitted in turn to each check.

On June 12, 1882, in Central California Colony, two checks of alfalfa, 290 by 130 and 290 by 200 feet, respectively, were irrigated at the same time with 1.2 second-feet. Water was applied from 9 a. m. to 8 p. m. The total amount supplied was equivalent to a depth of 0.49 foot over the whole area of the alfalfa. The soil was a sandy loam, with hardpan at 1 to 2 feet. This alfalfa was to receive five such irrigations during the season.

On the Gould Ranch, north of Fresno, one attendant in 1882 handled about 1 second-foot of water. With this amount of water orchard lands were irrigated at the rate of about 4 to 5 acres per day of twenty-four hours. The average depth of the water applied over the whole surface of the orchard was 0.40 to 0.50 foot. The orchard received two to three irrigations per season. The trees of the orchard are set about 16 feet apart in rows 24 feet apart. Water was run in small ditches along each row, and was made to stand around the body of each tree while irrigation was in progress. The surface of the ground was not leveled when the orchard was set out. The soil is a heavy, dark loam, with hardpan at an average depth of 5 to 7 feet.

About 4 miles northeast of Selma 2 to 3 acres of vines or trees could be irrigated in 1882 in one day of twelve hours with 1 second-foot of water. The soil is a sandy loam, with no hardpan under it. It bakes on the surface in drying. Ground water was then some 40 feet below the surface. The method of irrigation is that of running water in furrows between rows. Several such irrigations per season are given to trees and vines.

In the same vicinity in 1882, irrigation of grain with 2 to 3 second-feet was progressing at the rate of 3 to 4 acres per day of twenty-four hours. The method of irrigation was the furrow method. Furrows were 10 to 12 feet apart. The soil was thoroughly saturated by percolation. The amount of water absorbed was sufficient to have covered the entire surface to a depth of 1.42 feet. One irrigation at any time after harvest is sufficient to mature the grain crop of the next season. The soil is a sandy loam, which bakes after wetting, unless cultivated before drying. Hardpan is not continuous; where it does occur it is generally at 8 feet below the surface. Ground water is at 35 to 40 feet.

On June 12, 1882, in Central California Colony a small check of grapevines, one-fourth acre, was irrigated in fifty-five minutes. The check was level and all water standing in it at the end of the fifty-five minutes

was allowed to soak into the ground. The soil was still somewhat moist at the time this irrigation commenced. The soil is a sandy loam 1 foot deep, resting on a firm hardpan, through which holes were cut when the vines were set out. The amount of water supplied was 0.8 second-foot, and the total amount was sufficient to cover the ground 0.25 foot deep. The vines appeared thrifty and in splendid bearing. Such irrigation was repeated about every three weeks until the grapes had matured.

About a mile east of Selma, where the soil is a sandy loam 10 to 25 feet deep, with ground water at 24 feet, it was said in 1882 that 2 acres of wheat land could be irrigated in one day of twenty-four hours by one attendant with 1½ to 2 second-feet of water, equivalent to a depth of water over all of about 1.74 feet.

The foregoing statements must not be accepted as an indication of the ultimate duty of water on the Fresno plains. The area irrigated per unit of water will continue to increase, at least until irrigation produces no further permanent changes in the elevation of the ground-water plane.

Without attempting to express in detail the acreage irrigated per cubic foot per second of canal capacity or actual flow of water, it may be noted that the total volume of water brought to the vicinity of Fresno during the seventeen years 1879 to 1896 would at a very low estimate have covered to an average depth of about 0.8 foot per annum the entire 260,000 acres of the region through which the canals send their branches. It would have covered the 50,000 acres to whose surface water is actually applied to an average depth of 4½ feet per annum, or to a total depth of 75 feet. Some of this water has of course been consumed in sustaining plant life, more has been evaporated, but the most of it still permeates the subsoils of the irrigated region and of the lands to the west.

WILDFLOWER.

The Wildflower country is a small portion of the east-side plain of San Joaquin Valley just south of the Kings River delta lands. Its limits may be considered coextensive with the area covered by the Emigrant Canal and its branches. Sandy soils predominate, the heaviest being near Cole Slough in the southeastern portion of this region, and the lightest along its northwestern border. The usual strip of bad lands, strongly alkaline, is found at the south, near the overflow limit from Kings River. Hardpan does not appear in a continuous layer under the soil; it is found in spots or belts of small extent, generally 4 to 8 feet below the surface, and usually but a few inches thick.

For a number of years all the water used for irrigation near Wildflower was supplied by the Emigrant Canal. As this canal became unreliable as a source of supply (due mainly to litigation concerning

ownership of its head works), water from other canals, the Fowler Switch and the Centerville & Kingsburg, was brought into the same district.

The irrigating period while the Emigrant Canal was in full service continued from March to the end of August. All the water of the canal during that period was apportioned to the distributing and irrigating ditches, and was allowed to sink from these into the subsoils. The method of irrigation was essentially that of subsurface saturation, which will be fully described in the notes on the Mussel Slough country. Alfalfa fields are sometimes subdivided into small rectangular checks of one-half acre to 2 acres each, and receive an occasional flooding. The surface of the country is very smooth, and no leveling or smoothing of the surface was necessary, as at Fresno. All water delivered into a check is allowed to sink into the soil, which readily takes it. Orchards and vineyards are irrigated, while water is available, by conducting it between the rows of trees and vines in small ditches. Summer crops are irrigated by the furrow method. Before lands were irrigated ground water was here at 10 to 16 feet below the surface; it has risen, as the result of irrigation, about 6 feet.

LIBERTY AND MILLRACE SETTLEMENTS.

The region watered by the Liberty and Millrace canals is a continuation of the Wildflower country westward, and the same notes with reference to soils apply. Water supply has usually been restricted to a few months each year, and the process of subsoil saturation has been rather slow. Irrigation is accomplished by flooding in small contour checks or by filling small ditches or furrows between rows of trees, vines, corn, or vegetables. Water is so freely absorbed by soils that no drainage is necessary.

LAGUNA DE TACHE RANCHO.

This grant, which extends southwesterly along the north side of the main channel of Kings River a distance in a direct line of about 25 miles, from near Kingsburg to Summit Lake, embraces the major portion of the north-side delta lands. Its hydrographic features have already been dwelt upon, and but little more is to be said concerning the use of water upon it for irrigation. The surface of the ground is smooth; there are no irregularities except such as have been produced by Kings River waters. Predominating soils are deep, sandy loams. Some of the depressions near present water courses, particularly in the northwestern and northern portions of the rancho, have sedimentary soil. The upper portion of the rancho, along Cole Slough, is in the alkaline belt. The surface slope from east to west is about 4 feet to the mile. Near Kings River is a fine growth of oaks. Willow thickets abound near the river in the southern portion of the rancho.

The many delta streams have always furnished an abundance of water to subsurface strata, so that depth to ground water has never been very great—4 to 16 feet, varying somewhat according to locality, and no doubt also somewhat with the seasons. The local control of fluctuations in the elevation of the water table is one of the features of the method of irrigation. The canal supply is ample from February to August. Little or no water is put upon the surface of the ground. Tracts to be irrigated have ditches generally located on the slight ridges built up by former water courses, from which water sinks into subsoils. Surplus waters are drained from the flat depressions between these ridges by a simple system of drain ditches. Crops irrigated are principally natural grasses and cereals.

MUSSEL SLOUGH COUNTRY.

Description.—All of the Kings River delta south of the main channel of the river and west of Cross Creek is commonly known as the Mussel Slough country. Many water courses, locally called sloughs, former channels of Kings River, course through this region from north to south. The heads of most of these have long been filled with deposits from the river. Others have more recently been artificially closed. A great many have been made parts of the distributing system of the irrigation works of this region.

The surface of the Mussel Slough country slopes from northeast to southwest at the average rate of about 4 feet to the mile, which is only about one-half the fall of the ground's surface in the vicinity of Fresno.

The soil of this region is all sedimentary. Most of it is sandy loam, varying somewhat in texture and color in different localities. It is sandiest toward the east and northeast; heaviest toward the west and south, where it merges into the peaty clays of the swamp-land belt. From northeast to southwest, at Grangeville, a strip of land several miles wide extends through this region, whose soil is a dark, rich loam, generally considered of the best in the delta. All soils are deep, resting upon subsurface strata of sands and soft, sandy clays.

Before the construction of the irrigation canals in the Mussel Slough country, depth to ground water was 10 to 18 feet. It was found at greatest depth in the eastern and southern portions of the delta. Irrigation very soon brought the water table close to the surface of the ground, and throughout the irrigated portion of the south-side delta it does not now sink to over 8 feet below the surface. It has an annual fluctuation, rising during the spring months when canals are full of water, and falling again in the fall of the year. In some localities this rise is so pronounced that standing water appears in the depressions, forming ponds which do not entirely disappear until the close of the irrigating season.

Canal system.—The Mussel Slough country is supplied with water

for irrigation from Kings and Kaweah rivers. The former sends water through the Peoples, Last Chance, Lower Kings River, and Rhoads canals to the northern, central, and western portions of the south-side delta, while Kaweah River supplies water to its eastern portions through the Settlers and Lakeside canals. For about six months each year, commencing with February, Kings River furnishes an abundance of water for the canals leading from it. The canals from Kaweah River are not so copiously supplied with water, because that river is subject to greater irregularities of flow than Kings River. Their period of flow is not so long as that of Kings River canals, and is largely dependent on the conditions of the diversion of water at the head of St. Johns River, where conflicting interests of different irrigated regions have given rise to repeated modifications of natural channels. Ordinarily the flow of Settlers and Lakeside canals commences in January and continues to the end of June.

The total amount of water supplied to the Mussel Slough country by the canals above enumerated is sufficient to cover the entire area under these canals and their branches to an average of several feet per annum. It was sufficient in 1885 to cover the land which was then in actual cultivation in this part of the Kings River delta to a depth of about 4 feet.

Irrigation on a noteworthy scale commenced in 1870 in the Mussel Slough country when the Lower Kings River Canal was constructed. The construction and extension of the several other canals quickly followed. There has been but little extension of the canal system since 1880.

Each canal project (with the possible exception of the Mussel Slough Canal) had its origin with the settlers who needed water. The sole consideration in each case seems to have been the securing of a fairly reliable water supply at reasonable cost for use upon the lands of the projectors of each enterprise. This circumstance will account for the apparent duplication of canals; for, as the irrigated area was extended and additional lands were settled, it was but natural for the landowners of the new settlements to construct new canals and to control independent canal works. The seven canals that are or have been in use in the Mussel Slough country could well be replaced either by one main canal from Kings River or, perhaps better, by one such canal and one smaller one from Kaweah River.

The canals distribute water throughout the delta in a network of branches and natural channels, often so intertwined that large areas are benefited by the water of several canals at the same time. It happens, too, that lands whose owners have no claim upon water in any canal are here and there so favorably located that they are irrigated without cost to owners by the canals and ditches of their neighbors.

Method of irrigation.—The rainfall in the Kings River delta is only 9 inches per annum. Irrigation is necessary for the successful cultiva-

tion of all soil products. Cereals and alfalfa were practically the only cultures from 1870 until 1884. More attention is now given to fruit raising, to the cultivation of the grape, and to diversified farming.

To prevent wholesale inundation of south-side delta lands a levee is maintained along the south bank of the main channel of Kings River.

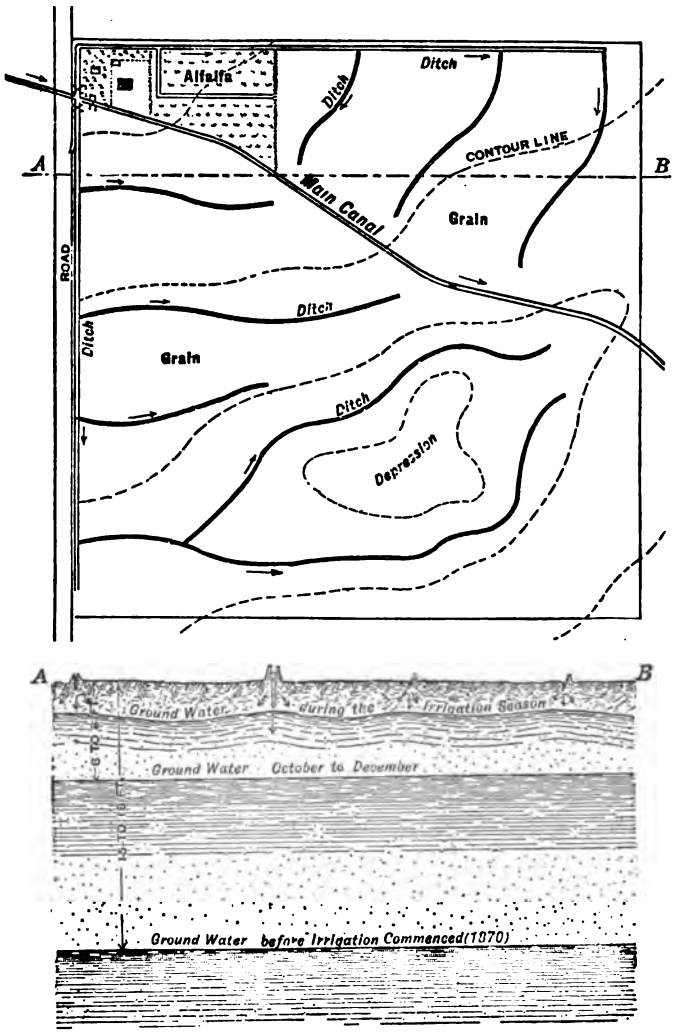


FIG. 21.—Irrigation by filling subsoils with water, Mussel Slough country.

The inflow of irrigation water into the district is controlled by means of regulators in the heads of the principal canals. The flow of water in some of the main canals and in most canal branches is sluggish, water being generally held at a very light grade, often by use of check weirs.

INDEX.

	Page.
Alfalfa, methods of irrigating	83, 84, 90
Alta irrigation district, work in	52–57
Bacon & Crossmore Canal, description of	29–30
Bahwell Ditch, description of	33
Barton Ditch, description of	57
Bliss & Hyde Ditch, description of	25
Bostwick Cut, description of	33
Brown Ditch, description of	25
Burch Ditch, description of	32
Catron Ditch, description of	25
Cameron Creek, course of	13
Cameron Creek Company, operations of	29
Centerville Ditch, description of	47–48
Centerville & Kingsburg Canal, description of	50–52, 75–76
Chatten Ditch, description of	31
Cole Slough, course of	41–42
Consolidated Peoples Ditch, description of	22–25
Crescent Canal, description of	62
Cross Creek, course of	13
Crowley & Mehrtens Ditch, description of	34
Curtis Ditch, description of	17
Curtis & Lindsey Ditch, description of	16
Cutler & Higgins Ditch, description of	31
Davis Ditch description of	25
Deep Creek course of	12, 14
Dennis & Jordan Ditch description of	57
Duty of water, observations on	79–85
Elbow Ditch No. 1, description of	16
Elbow Ditch No. 2, description of	16
Emigrant Canal, description of	57–58
Enterprise Ditch, description of	43
Evans Ditch, description of	32
Evans & Turner Ditch, description of	32
Evaporation and seepage, loss of water by	74–78
Extension Ditch, description of	25–26
Farmers Canal, description of	27–28
Fowler Switch Canal, description of	48–50
Fresno Canal, description of	43–47
Fresno Plains, canal system of	73–74
description of	71–73
effect of irrigation on water table in	78–79
loss of water by evaporation and seepage in	74–78
methods of irrigation and duty of water in	79–85
Fulgham Ditch, description of	33
Glenn Ditch, description of	57
Goshen Ditch, description of	20–21
Grant Canal, description of	58–62
Hall, W H., cited	11, 39
Hamilton Ditch, description of	22
Hayes Lower Ditch, description of	21
Hayes Upper Ditch, description of	20–21
Hicks & Weston Canal, description of	20
Irrigation, effect on water table of	78–79
methods of	35–38, 79–85, 88–91
Jacobs Canal, description of	69
Jennings Ditch, description of	20
Judd Ditch, description of	30–31
Kaweah Canal, description of	26–27
Kaweah River, canals and ditches from	14–35
hydrography of	11–14
Kaweah and Mill Creek Water Company, operations of	31
Ketchum Cut, description of	34
Kincaid Ditch, description of	57
Kings River, canals and ditches from	42–69
course of	40–41
hydrography of	39–42
Kings River and Fresno Canal, description of	42–43, 74–75
Laguna de Tache Canal, description of	58
Laguna de Tache Rancho, irrigation on	58–59, 61, 86–87
Lakside Ditch, description of	18–20
Last Chance Ditch, description of	65–67
Lee & Thompson Ditch, description of	25
Liberty Canal, description of	58
irrigation from	86
Longs Canal, description of	33
Lower Kings River Canal, description of	67–69
Matthew Ditch, description of	16–17
Mill Creek, course of	13
Mill Ditch, description of	33
Millrace Canal, description of	58
irrigation from	86
Modoc Canal, description of	20
Morrow Ditch, description of	57
Mussel Slough country, irrigation in	87–91
Mussel Slough Ditch, description of	64–65
Newell, F. H., letter of transmittal by	9
Oaks Ditch, description of	31–32
Ogden Ditch, description of	21–22
Orchards, methods of irrigating	83, 84, 86
Outside Creek, course of	14
Packwood Creek, course of	13
Packwood Creek Canal, description of	29–30
Pennebaker Ditch, description of	25
Peoples Ditch, description of	62–64
Pogues Lower Ditch, description of	21
Pogues Upper Ditch, description of	21
Reeds Ditch, description of	58
Rhoads Canal, description of	69

	Page.
Rice Ditch, description of	25
Rocky Ford Ditch, description of	29
Rodgers Ditch, description of	20
St. Johns Channel, course of	12, 13
Seepage and evaporation, loss of water by	74–78
Selma irrigation district, situation of	52
Settlers Ditch, description of	17–18
Seventy-six Canal, description of	52–57
Soils, nature of	37, 72, 85, 87
Sunset irrigation district, work in	69–70
Swanson Ditch, description of	25
Sweem Ditch, description of	48
Teague Ditch, description of	25
Trees and vines, method of irrigating	83, 84, 86
Tulare irrigation district, work in	34–35
Tulare Canal, description of	28–29
Uphill Ditch, description of	17
Venice Ditch, description of	16
Vines and trees, methods of irrigating	83, 84, 86
Visalia Creek, course of	12, 13
Wahtoke Creek, course of	42
Wahtoke Reservoir, map of	53
Water, duty of	79–85
Water table, effect of irrigation on	78–79
Watson Ditch, description of	32–33
Weston Ditch, description of	17
Wildflower, irrigation near	85–86
Wutchumna Canal, description of	14–16

O

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894-95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893-94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895-96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett, and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896-97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton, and "Reservoirs for irrigation," by J. D. Schuyler.

1898.

Nineteenth Annual Report of the United States Geological Survey, 1897-98, Part IV, Hydrography.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton, and "A preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1898.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas, by W. F. Hutson, 1898.
14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.

In press:

19. Irrigation near Merced, California, by C. E. Grunsky.
20. Experiments with windmills, by Thomas O. Perry.

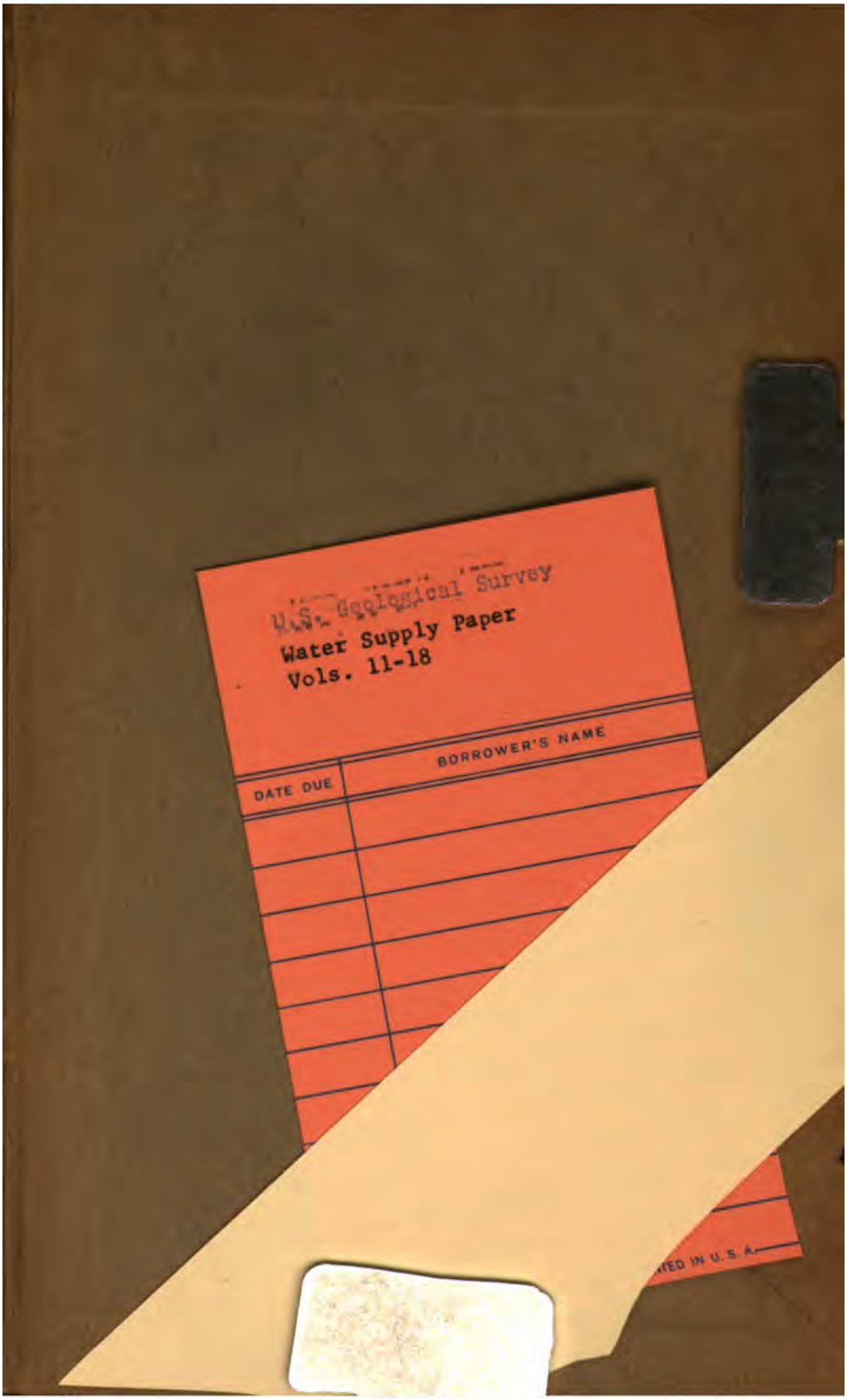
In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L., vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Survey is 1,000. This quantity falls far short of the demand, so that it is impossible to supply all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or who have furnished data. Requests made for a certain paper and stating a reason for asking for it are granted whenever practicable, but it is impossible to comply with general demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.


U.S. Geological Survey
Water Supply Paper
Vols. 11-18
DATE DUE
BORROWER'S NAME

3 2044 102 941 978